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An Investigation of the Responses Made in Learning a Multiple Choice Maze

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CHAPTER I

Introduction *

Although numerous studies of maze learning have been carried out, using extremely varied types of mazes, most of these studies have had as their purpose the comparison of two different groups in a learning situation. Less attention has been paid to the various kinds of learning, the methods of attack, and the difficulties encountered. It would seem that a consideration of the maze problem with reference to the methods of attack and the organization of the maze parts should prove valuable for learning in general, since many of our habits are of a serial or maze type. Hamilton (14, 15) early pointed out and experimentally showed the importance of considering the types of errors as well as the number. The study of learning curves and of interfering factors must be related to the learner's organization of the maze, whether obtained from the objective record or as a verbal report.

A maze may be defined as a series of situations connected in an arbitrary manner, permitting the subject to make two or more types of response in each situation and accompanying each type of response with a differential reaction upon the subject by the environment. A multiple T maze is a succession of choice situations, connected by the retaining walls. The mental maze (*e.g.*, Peterson's) likewise offers a series of choice situations connected by the verbal instructions given to the subject. The former type is thought of as a space maze, although this may only be the viewpoint of the experimenter or observer. The latter is not classed as a space maze, but again the subject's perception

* I wish to express my appreciation to Professor Samuel Renshaw for his unstinted aid, advice, and encouragement rendered throughout the course of this investigation. I am indebted to Dean George F. Arps, Chairman of the Department of Psychology, and to Dean William McPherson of the Graduate School of the Ohio State University for funds spent for apparatus and assistance in analyzing the records.

of it is the deciding factor. In classifying learning problems and in determining their difficulty too much can not be said against the ignoring of the subject's point of view. It is in this sense that studies of the way in which the material is organized should constitute most valuable contributions.

CHAPTER II

The Experiment

1. *Problem*

The purpose of this experiment was to investigate the responses made by human beings in learning an electrical maze of multiple choice design with special reference to

(1) the grouping together of various parts of the maze,
(2) the associations formed between remote parts,
(3) interference between different parts,
(4) the variability of the learner's responses,
(5) inefficient types of responses, and
(6) miscellaneous factors.

2. *The Electrical Maze*

An electrical type of maze (16) was used. This type of maze offers a certain number of push buttons or choices to the subject. The pressing of a certain one of these constitutes the correct response and is analogous to entering the right alley of an ordinary maze, while the pressing of any other button is equivalent to entering a cul-de-sac. When the right button has been pressed, the apparatus presents a new situation to the subject comparable with the next place of choice in the usual maze. An important difference exists in the fact that the subject using an electrical type of maze can not retrace his steps. The maze therefore consists of a sequence of situations, each of which offers one right choice and several wrong ones, and the subject has learned the maze when he can choose correctly in each successive situation. In general the term *maze* is used in this paper with reference to this electrical type of maze.

3. *Apparatus*

The apparatus consisted of (1) a four-bank portable Corona typewriter, (2) a stepping device, (3) a bank of 100-ohm tele-

phone relays having four makes, and several other relays, (4) a 1/10-H.P., 1800-R.P.M. synchronous A.C. motor fitted with a gear reducer 100 to 1, (5) contact strip, (6) paper guide and support, (7) cardboard screen, (8) switches, and (9) a red light.

Plate I shows a side view of a portion of the apparatus. (In the following description the letters and numbers in parentheses refer to the parts similarly labeled in Plate I and Figure 1.) The typewriter was placed upon a table 30 inches high, close to the edge and near the subject's chair. A screen (A) 17 inches high and 16 inches wide, of gray cardboard, placed across the typewriter, restricted the subject's view to the bank of keys. To the right of the typewriter on the table was the red light (B), made by housing a bulb in a small wooden box with a red glass screen. Underneath the typewriter was placed the contact strip (C) which raised the near part of the typewriter about half an inch. This wooden contact strip (Figure 1) fitted into the bends on both sides of the typewriter frame, thus ensuring its accurate location. On the wood were mounted a series of small spring brass contacts staggered in three rows. These contacts were arranged in pairs facing each other, one pair directly below the lever of each letter key on the typewriter. The contacts stood ½ inch high with tapered and turned-back ends. The two contacts of any pair were separated by 1/16 inch at the bottom where they were mounted on the wood but their upper parts almost touched. The depressed lever of the key penetrated between them to within ⅛ inch of the wooden base strip. One electrical lead went to each pair of contacts, and a common lead was soldered to the frame of the typewriter.

The wiring diagram and a few details of the apparatus are shown schematically in Figure 1. Switch S1 controlled the current supply from the 6-volt storage battery (1). From this switch the current passed by way of the distributor (2) of the stepping unit to one of the relays (3) of the relay panel and back to the battery. This relay (3) closed four make contacts (4, 5, 6 and 7). Another lead from switch S1 passed to the frame of the typewriter (8). The depressing of the keys permitted the current to pass to the contacts (9) and on to the

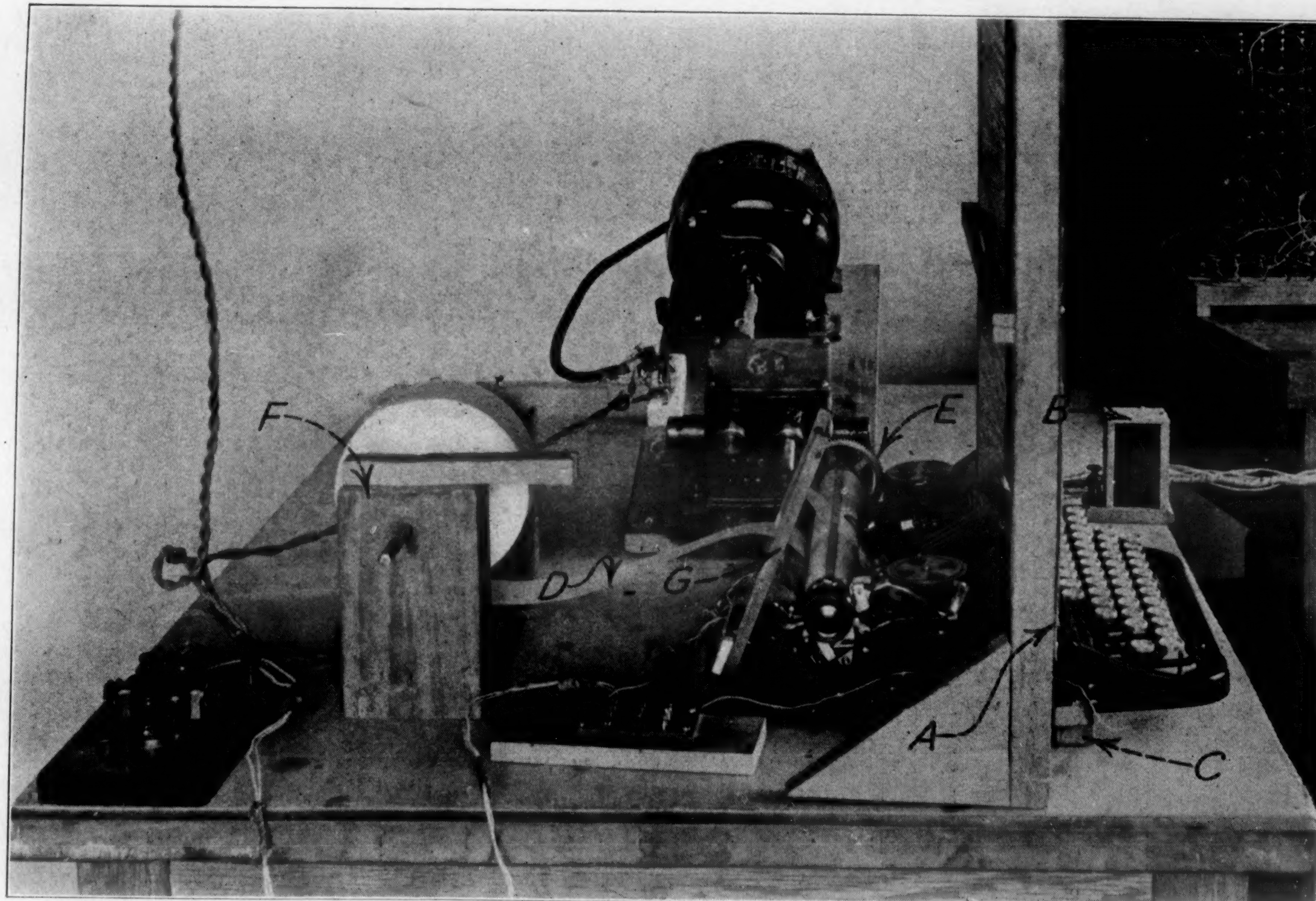


PLATE I. Electrical Typewriter Maze

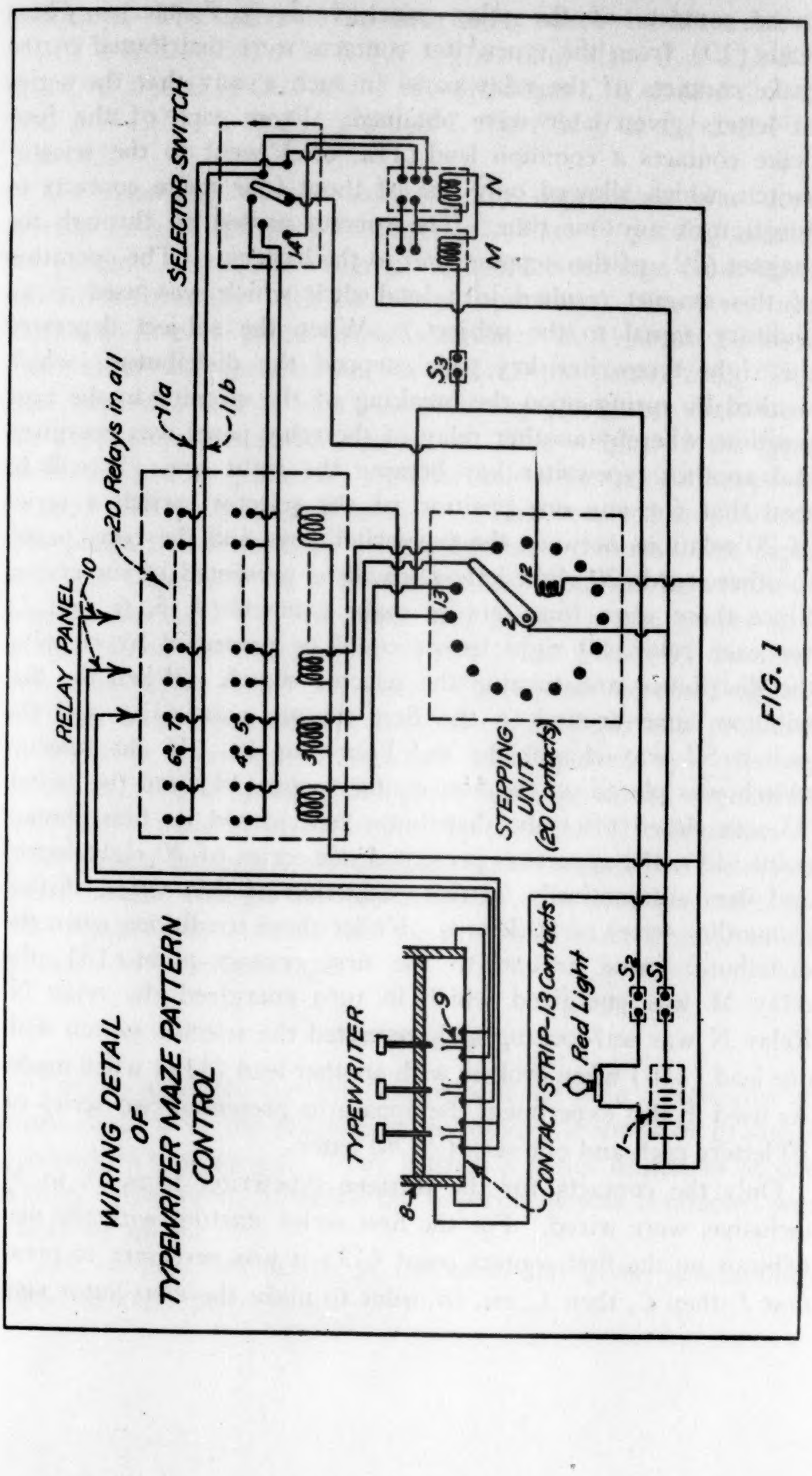

WIRING DETAIL
OF
TYPEWRITER MAZE PATTERN
CONTROL
RELAY PANEL
10
20 Relays in all
11a
11b
SELECTOR SWITCH
14
M
N
S_3
STEPPING UNIT
(20 Contacts)
12
13
2
TYPEWRITER
9
8
CONTACT STRIP-13 Contacts
Red Light
S_2
S_1
1

FIG. 1

make contacts of the relay panel (4, 5, 6, 7, etc.). These leads (10) from the typewriter contacts were distributed to the make contacts of the relay panel in such a way that the series of letters given later were obtained. From each of the four make contacts a common lead (11a, etc.) went to the selector switch, which allowed only one of these four make contacts to function at any one time. The current passed on through the magnet (12) of the stepping unit to the battery. (The operation of this magnet resulted in a loud click which was used as an auditory signal to the subject.) When the subject depressed the right typewriter key, this stepped the distributor (which worked by spring upon the breaking of the circuit) to the next position, whereby another relay of the relay panel was energized and another typewriter key became the right one. It will be seen that for any one position of the selector switch a series of 20 relations between the typewriter keys and the relay panel, in other words 20 right letters, could be presented in succession. Since there were four sets of make contacts (4, 5, 6, and 7) for each relay, 80 right letters could be presented by stepping the distributor and turning the selector switch. When the distributor came around to the first contact point (13) and the switch S2 was closed, the red light was lit. If the selector switch was placed on the first contact point (14) and the switch S3 was closed after the distributor had passed its first contact point (13), the apparatus presented one series of 20 right letters and then automatically, at the completion of this series, shifted to another series of 20 letters. Under these conditions when the distributor came around to the first contact point (13), the relay M was energized which in turn energized the relay N. Relay N was self-locking and connected the selector switch with one lead (11b) when broken, with another lead (11a) when made. As used in this experiment the apparatus presented two series of 20 letters each and one series of 40 letters.

Only the contacts for the thirteen typewriter keys, A to M inclusive, were wired. For the first series starting with the distributor on the first contact point (13) it was necessary to press first *J*, then *C*, then *L*, etc, in order to make the distributor step

each time. The letters of the three series were: 1st Maze *J C L A M I L E G A L G J M L I K E I A;* 2nd Maze *B A L L I F L E D C B A G A G E M B J K;* 3rd Maze *C H E M I C A L K G L A C I A L D E L I G I B L E J I M B E C I L E F L E D G E.*

The recording of the subject's key depressions was done directly on a 2 inch strip of paper (D, Plate I) passing around the platen. A wooden wedge prevented the carriage from being moved horizontally with each key depression. The lever was shifted so that the platen turned smoothly. A 2½ inch, 80-tooth gear wheel was fastened to one end of the platen rod. This gear meshed with a ¾ inch gear on the speed reducer shaft when the typewriter was placed against it. The weight of the typewriter held these gears (E) together unless the subject happened to seize the typewriter and move it. (This occurred only twice.) The platen therefore made 5.4 revolutions a minute. The paper roll was supported on a horizontal rod mounted between two wooden blocks (F). The paper was guided to the proper part of the platen by two upright square brass posts (G) mounted two inches apart on a brass plate. These posts were laid against the back of the typewriter. Tension on the paper was produced by a string with weight attached which passed over the top of the roll. The speed of the paper was augmented slightly by wrapping a sheet of paper around the platen; 9.21 millimeters of paper passed through every second. Since the speed of the motor was constant enough for the purposes of this experiment, no time marker was installed and the time was taken directly as the distance on the record tape.

4. *Method*

The 40 subjects for this experiment were in practically all cases students in the elementary psychology sections or graduate students in psychology. They learned a series of letters at one sitting. The room in which the experiment was conducted was relatively quiet.

The subject was seated at the table and given substantially these instructions:

Your problem is to learn a maze of twenty letters in the order in which they occur, so that you can go over the letters three times in succession without a mistake. You will press different keys until you press one that gives a loud click. This is the first letter of the maze. Then you will press more keys until you hear another loud click. This is the second letter of the maze. You go on until this red light shows you that you have found all the twenty letters. When the red light goes out, you will start again and press the first letter that you found would click last time, and then the second and so on. You will go through the maze again and again until you press only letters that click and do this three times in succession. All the twenty letters are to be found between A and M, including A and M, so it is useless to press any letter below M in the alphabet. Furthermore you may be pressing keys so quickly that you will hear a key click as you press another one down. Just remember which key it was that clicked in that case. You may learn the maze any way you like and take as much time as you want.

Most of the subjects understood the instructions, although they were at first somewhat puzzled over the fact that there were only thirteen letters to choose from and the maze consisted of twenty letters. Several immediately asked if a given letter was repeated. I reminded the subject of the previous instructions but did not give a direct reply. There were other difficulties such as the fact that the keys had to be pressed in just the order in which they were found to click. In all cases I answered by referring to the somewhat meager instructions. All subjects solved these problems for themselves.

After the subject had completed the first maze by pressing the proper keys without error three times in succession, he was requested to stand with his back to the typewriter and repeat the letters in order, saying them aloud as fast as he could. I sat at the typewriter and typed the letters whether wrong or right as he gave them. If I felt that a subject was spacing the letters evenly on my account, I urged him to go faster. This usually broke up the even spacing and gave a grouping of the letters which was what I desired.

The subject was next asked to learn the second maze and upon completion of this maze to repeat the letters orally. Then I asked the subject to tell me how he went about learning the mazes. Where it was necessary, I asked concerning the grouping of the letters and the pronunciation, but as a rule I tried to avoid any suggestion and simply had the subject talk until I obtained the desired information. This precaution, however, was not

entirely successful and at least one subject profited from the conversation when it came to the learning of the third maze. Three subjects were questioned after the first maze as well as after the second.

Except in three cases the third maze was learned a week later at the same hour without repetition of the formal instructions. It was repeated orally by the subject and he was questioned as to how he had learned it. This time I inquired more fully into the groupings, since there was no future result to prejudice.

Most of the subjects were required to type the alphabet several times as quickly as possible. They typed the letters from A to M in order to give some indication of their familiarity with the keyboard. This test was given either after the completion of the first or of the second maze.

5. *Results*

Parts of the original data, from which the calculations and correlations given in the subsequent portions of this report were made, are incorporated as an appendix in a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy. This thesis, bearing the same title as this monograph, is on file in the office of the Graduate School of the Ohio State University.

CHAPTER

Grouping in Relation to Maze Performance

1. *Problem*

When a long list of letters, syllables, or right and left turns is learned, certain parts seem more difficult and the subject continues to err on them after he responds correctly on the other parts. These errors break up the maze into a number of parts and are indicative of an organization of these parts as opposed to a limited or non-organization of the error parts. After these errors are eliminated, the performance usually does not run smoothly but is characterized by certain pauses, hesitations, and reductions in speed. These breaks, to whatever they may be due, also show that an organization of the series into sub-wholes is present. How this organization of the material comes about is a problem of much practical as well as theoretical interest. Is it inherent in the material? Does the subject force the organization by arbitrary groupings? Are the groups easily susceptible to modification and how are the larger complexes built up? The rôle of organization in maze and serial learning is shown by the difficulties encountered in proceeding with a performance when the start is made in the middle, the fact that the subject often makes not one but several errors in succession on a part of the maze previously run without error, and that, as Nagel (34) found, terms taken from the middle of a learned series frequently failed to reproduce their associates.

2. *History of Grouping in Serial Learning*

Practically every writer on serial learning has reported some type of grouping. Mueller and Schumann (33) found that their subjects formed rhythmical groupings when they learned nonsense syllables. The subjects of Perkins (37) reported that the maze was broken into sections with the long paths as points of

reference. In one maze there were roughly three such parts and the subjects learned the general direction of the path for each part. Even after certain blinds had been learned, the subjects hesitated at points. Freeman (11) gives in the protocols of his subjects evidence that they tried various groupings such as a 4, 4, 4, 3 distribution of a series of 15 syllable pairs. Ogden (35) in applying Gestalt psychology to the learning of serial orders says that memorization would be impossible without forming a unified whole out of the series, with certain subgroupings occasioned by beat, melody, measure, and specific articulatory progression. Evidently some kind of grouping is the ordinary experience of the serial learner, whether he is attacking verbal or motor material.

3. *Kinds of Groupings*

Grouping may be arbitrarily imposed on a series or may result from certain characteristics of the series itself. Even in the former case the number of terms in a series necessarily influences the grouping, as evidenced by the fact that the twenty- and forty-letter mazes were divided by some subjects into groups of five terms each. Freeman (11) reports a grouping of three series of five pairs each for one subject. In my experiment only three of the thirty-nine subjects grouped the first and second mazes arbitrarily. Two of these three grouped the third maze in a similar fashion; that is by fives. Two of the subjects kept these groupings ordered by counting the letters off on their fingers. However, all of the remaining subjects showed some sort of grouping.

An examination of the results of Maze 3 showed that the letters most frequently used as the beginning of a group in order of frequency were: (1) the first letter in the maze; (2) a consonant preceded by a vowel and followed by *I* and *M,* etc.; (3, 4, and 5) consonants preceded by consonants; (6) a consonant preceded by a vowel; and (7, 8, 9, and 10) consonants preceded by consonants. Analysis of the maze itself showed that it contained 24 consonants and 16 vowels. The tendency to begin groups with consonants was thus clearly shown. Moreover,

9 of these 24 consonants were preceded by consonants. Seven of these 9 consonant-preceded consonants were found among the 10 most frequent beginning letters. A parallel to the English orthographic practice of dividing words between consonants was therefore established. This maze, and the other two as well, seemed definitely to suggest certain groupings to the subject, which may account for the lack of arbitrary or imposed groupings.

The first four or five letters as related to the memory span offered a natural group. If these letters contained a word, as they did in the second maze (*ball* was the word), the subject often grasped this word (24 subjects out of 39 did) and started a new group with the next letter. Here again a word (*if*) was found and then another (*led*) (about 50 per cent of the subjects). If the whole maze had been composed of words following each other, half the subjects would presumably have followed that grouping through. The *C,* however, occurring after *led,* acted as a deterrent for the next word group (*bag*), which was reported by only one-fourth of the subjects. This same influence was observed in the third maze, where the *K* after *chemical* prevented the combination *glacial* from emerging. A letter was seldom left alone, but if a group was closed, such as *led* or *chemical,* this letter was used as an initiator of the next group *C B A* or *K G.* It was rarely tacked onto the preceding word group.

TABLE I

The Number of Groups and the Number of Letters in the Groups for the Different Mazes. Taken from the Reports of the Subjects

Grouping	I Number of Groups	I Number of Letters	II Number of Groups	II Number of Letters	III Number of Groups	III Number of Letters
Words	31	109	89	270	100	484
Defective words	21	83	18	92	58	259
Initials	26	69	15	36	15	50
Abbreviations	10	22	4	9	7	14
Sounds	13	63	8	26	43	218
Key position	37	123	30	95	17	76
Unidentified	66	199	38	102	49	153
Alone		48		39		61
Dropped		26		12		11
Special orders	6	20	29	77	1	2
Overlapping	9	11	10	11		33
Number of subjects	38		38		33	
Average size of group		3.3		3.1		4.3

Inspection of the records of the subjects showed the grouping practices plainly and the reports of the subjects confirmed these groupings and differentiated one type of grouping from another. The reports of the subjects were checked against their actual records to determine the extent of the variation between reported and recorded groupings. The difference was small: roughly 5 to 10 per cent.

Table I gives an arbitrary classification of these groupings as words, initials, abbreviations, position groupings, etc. In the first column is found the number of groups and in the second column the number of letters for any type of grouping. The average length of a group was rather small, 3.6 letters.

4. *Verbal Groupings*

The subjects combined letters to form groups with verbal significance. They used words, sounds, abbreviations and initials. The letters *J C* encountered at the beginning of the first maze suggested initials of names quite frequently. Perhaps this was because *J* is in more general use as an initial letter of names than of words. Religious fervor accounted for the grouping *J C* in one case. Abbreviations were less common than initials. Sounds as groupings were used comparatively more in the third maze.

Besides the actual words, of which a limited number were found in the mazes, the subjects resorted to so-called " defective " words. The defective words were formed from groups very similar to some real word and were often pronounced as the real word. The series *D E L I G* was identified with the word *delight,* for example. One might assume that these defective words would constitute a less efficient means of memorizing the maze, but there is no evidence to show that the deviating parts *CIEL* (French word) for *C I L E* caused much interference. The results of correlating the kinds of groupings with the performance of the subject as measured by trials (Table II) showed that the relation between the trial criterion and the amount of defective words grouping was the greatest.

It will be seen from Table I that the number of actual words reported for the first maze was greater than the number of

defective words. Evidently it was possible for many of the subjects after a certain number of trials to get the words actually in the maze, but not to construct these " near " words. If we consider that ease in learning is in part a matter of ease in forcing new groupings into old and familiar forms, then the

TABLE II

Correlations Between Number of Trials Required to Learn the First Maze and the Types of Groupings Used

Number of trials and	r	Number of trials and	r
Words	–.31	Position	.40
Defective words	–.52	Unidentified	.15
Sounds	–.15	Alone	.14
Abbreviations	–.32	Letters dropped	.31

quick learner should have organized the whole maze in terms of these near-words while the other learner was still looking for the more explicit aids—the actual words or special key combinations contained in the maze. The third maze gave an excellent illustration of this. The quick learner organized the maze into near-words, sounds, and other combinations, associating these with familiar forms. Perhaps one might look for a rule of " assimilation " or " similarity," such that quickness of learning is related to the degree to which a subject can interpret new material in terms of old arrangements. Evidently the recognition of the letters *I F L E D* as *flied* involves a greater ability to see relations than the recognition of *L I K E* as *like.*

Words appearing at the beginning and at the end of a series were favorably situated for identification and utilization. Maze 3 showed this. The words *chemical* and either *fledge* or *ledge* were recognized (with one exception) most frequently. *Glacial* and *imbecile,* the two words on either side of the middle word, came next in frequency; but the middle word itself was recognized but once.

Guilford (12) tried to determine experimentally the rôle of form in learning by giving series of numbers and nonsense syllables, etc., bound together by a general principle or form. Subjects who recognized this principle learned the series more quickly. The correlations given in Table II emphasize the same point, with the exception that the emergence of the actual forms

(words) seemed less important than the utilization of the other imperfect (*i.e.,* somewhat unfamiliar) groupings (*e.g., D E L I G*), which, however, occurred more frequently. Association of these groups, or to use a Gestalt expression, structuring them as familiar terms (*delight*), enabled the subject to learn the maze most quickly.

Sometimes verbal methods gave rise to peculiar errors. One subject memorized the first maze using the letters as initials of words. The series *J C L A* was identified with the phrase *Jack came left Ann,* except that since *Ann* was the name of the subject, she repeated it as *Jack came left me* and struck an *M*. The pronunciation of *gib* with a soft *G* sometimes led to the striking of *J*.

Many groupings were made in terms of the sounds of the combination of letters without attaching any specific meaning. For example, the series *L A C I* or *L A C I A L* of the third maze was frequently pronounced. When the subject was asked concerning this special type of grouping, he sometimes replied that it seemed like a word or like a foreign word. This seemed to show that familiarity with the sequence of letters helped in learning them. Another subject who experienced great ease in learning the sequence *E F L E D G E* could give no reason other than that the letters seemed to come naturally. Guilford (12) maintains that where the forms remained unrecognized, learning was not easier than in those series without special forms. This is a point which should be tested further.

5. *Position Groupings*

Table II shows that those subjects who depended most upon position groupings to aid them in mastering the maze tended to show the poorest scores. The groupings could have been classified roughly into two types: (1) the kinesthetic or movement type and (2) the static or form type. This was not done, because of the difficulty in differentiating between them, since the subjects were not trained observers and were very ready to accept suggestions implicit in the questioning. Subjects reported criss-cross arrangements, circles, and other geometrical forms. Right-

left descriptions and identification in terms of the rows on the typewriter were common. Other subjects reported a sequence of letters in terms of upward and downward movements of the hand. Rehearsing of the right letters was done by some subjects by hand movements on the keyboard. One subject, however, went through the motions of writing the letters on the top of the table. Many of these position groupings were later changed into verbal groupings during the course of learning the maze. For one subject *G A L* was " back and forth in the middle " at first and later a pronounced word. This fits in with the greater tendency to employ verbal groupings found in the second and third mazes to be discussed in a subsequent portion of this paper.

6. *Unidentified Groupings*

All of the letters which the subject grouped, but with which he made no reportable associations of any kind, were put in this class. No appreciable correlation between the number of trials and this type of grouping was found for the first maze.

7. *Letters Not Grouped*

Some letters were not grouped but either left alone or omitted in making the report. The correlation between the number of trials and the letters left alone was small. Some of the more efficient subjects used these single letters in order to make the best grouping arrangement of the rest. The *led c bag* sequence of the second maze illustrates this point. Furthermore, the single letter was not really left alone but was organized in a grouping of the sub-groups in the above case.

8. *Complex Building*

Sometimes subjects combined two or more original groupings to form a complex or larger grouping. Examples of this were found in the learning of all three mazes, although the number of subjects building complexes was small. In the third maze the word *chemical* (reported by half the subjects) was formed by some subjects from the first natural grouping *C H E M I* or *C H E M* and the next grouping *I C A L* or *C A L*, after they

had been through the maze several times. In the second maze the first word group *ball* was developed, and in nine cases the defective word *bailiff* was reported. In one case the word *be,* the letter *C,* and the defective word *ill* were combined to form the group *B E C I L,* which was thought of as *bacillus. Jimbecile* was used by some subjects as the fusion of *jim* and *imbecile.* This illustrates another type of complex building, that of overlapping groups. The number of overlapping letters was remarkably few, as Table I shows. It is quite possible that the subjects did not report the full number of cases of overlapping. In some cases the subject reported two groups but ran them together as one punching-group on the record.

The effect of pronunciation in the building of complexes and even of groups was important. Certain cases occurred where the pronunciation of *ch* probably interfered with the building of the word *chemical.* One subject formed the defective word *chemise,* another *Chicago. Chum* and *chime* were two other variations, while in one case the *C* was dropped and the *H* pronounced in the word *hem.* With the exception of *chemical* only one case occurred where *ch* was given the hard sound. This was in the defective word *chemistry,* which strangely enough was retained throughout the learning of the series as such.

Guilford (12) states that the more general forms come first and the details later. Perkins (37) found that the general direction of the maze and the areas were first recognized and later the specific turns were filled in. This tendency is apparent in the present experiment in the sense that the subject seemed first to have a general idea of where the letters belonged and learned later the specific locations or places. On the other hand Guilford also brings out evidence to show that forms are built up by induction, *i.e.,* noticing the relation of one term to another. This question will be further discussed in Chapter IX of this report.

Serial responses depend upon the proper "contexts" or "attitudes" for their initiation. Accordingly, when the situation gives several terms or cues, the whole may be perceived just as in the case of reversible perspectives and hidden figures. In maze learning the subject experiences successively relations

between different parts of the maze. These relations are often sufficient to call up a whole situation or whole form or whole grouping. The whole form or grouping is most easily remembered because it is related to previous experience or is simpler (as for example a general orientation or direction in maze learning). The successive terms which gave rise to the whole form are forgotten because they are many and complex. Thus the subject may feel that he has the general idea of the maze or the general form and may not know how it originated. Successive trials either confirm this form as correct or show it to be unsuited. In either case an attempt is made to learn the specific elements in terms of the whole. Defective words are forms, and sometimes the individual expects that the maze will correspond exactly to them. These forms may be brought about in the same way that misspelled words are perceived as correct. A part of the total situation is sufficient to bring about the response. It may be assumed, as previously stated, that the person who can pick up a form with the fewest number of cues, *i.e.,* the subject who forms these defective words, is the most intelligent, and he seems so indeed from the standpoint of maze learning.

The fact that complex building and overlapping are relatively infrequent shows that organization of the maze does not have to proceed very far before the usual criterion of learning is satisfied. The relation of complex building to overlearning should be investigated, since it is closely related to the elimination of excessive acts. When a maze is learned or when some performance is acquired, the social pressure is usually released. Does the subject continue to improve? Does he change his methods of attack so that he may perform more efficiently? Experience seems to show that the organism is satisfied with learning just as much as is necessary and no more. Therefore, we should expect that after certain parts of the maze had been grouped and learned, no complex building would take place in those parts. In other words, the subject would be satisfied with what he had learned and set about organizing the other unlearned parts. This seemed to be the case, although no quantitative results can be given.

9. *Effective Methods*

Warden (45) pointed out in an experiment with a stylus maze that of the different types of imagery used in mastering this maze the verbal type was the most effective, the visual type less so, and the kinesthetic type least. Subsequent investigations have in part affirmed the relative efficacy of the verbal type. Koch (26) in a maze study of blind and seeing subjects found that the blind rarely gave themselves verbal instruction, which may have accounted for their inferior performance. Barlow (2) had school children learn nonsense syllables with full articulation (pronunciation) and restricted articulation (reading without silent pronunciation) and found that the first method resulted in the reproduction or remembering of more syllables. Thirty-three subjects with decided verbal attack made an average of 28.7 errors each (scholastic aptitude test mean 583), whereas twenty-six subjects with motor methods averaged 63.7 errors (test mean 513) according to the results of a maze study by Scott (42). He further found that as the subjects learned more mazes, they gradually depended more upon a verbal type of imagery. This shift is noticeable in the results given in Table III for the present experiment, although the nature of the mazes may account for it. Scott (42) believes that the greater reliance upon verbal methods is one of the reasons for the reduced scores found in mastering the later mazes. The third maze in the present experiment required proportionately fewer trials than the first and was attacked predominantly by verbal methods. Two of the subjects mentioned this change, saying that they had discovered they could learn more easily using words and sounds.

Table III presents the correlations between combined sounds and words and the different measures of learning for the three

TABLE III

Correlations Between a Combined Score for Sounds and Words and the Different Measures of Learning the Maze

	Maze		
	I	II	III
Combined Score and	r	r	r
1. Total time	–.30	–.40	–.56
2. Errors	–.40	–.43	–.61
3. Trials	–.31	–.30	–.53

mazes. Again the shift to greater relationship between verbal methods and maze accomplishment with each succeeding maze is shown. A further fact in line with this general shift is the previously mentioned change from position groupings to verbal groupings during the learning of a single maze. Husband (24) describes a class of subjects which learned the maze partly in a motor manner, but finished by counting the turns (verbal). He corroborates Warden's findings as to the relative efficacy of verbal methods.

The results given in Table II link up with the above conclusions showing as they do that verbal methods (words, sounds, and abbreviations) correlated more highly with excellency in maze performance as measured by trials than did position, which may be looked upon as largely visual or kinesthetic. The unidentified groupings, which, for the reason that they are unidentified, may be largely motor in nature, showed the same sort of relation as the position groupings. These reports bear upon the finished maze performance. It has not, however, been shown that verbal self-instruction or attack is more efficient throughout the learning of the maze. Nor can these verbal methods be expected to produce results in dealing with any kind of learning problem. Renshaw (40) has shown that verbalization is detrimental during the early stages of pursuitmeter learning.

10. *Conclusion*

Grouping occurs in maze and serial learning.

Verbal and motor types of grouping appear to be most prevalent.

Verbal grouping is more effective than motor grouping.

There is some evidence of a shift from motor to verbal grouping during the period of learning.

In some cases small groups are combined to form still larger groups. Pronunciation plays a part here.

Groups are identified with similar groups from past experience. This shortens learning.

In general, grouping is a necessary phenomenon in learning and apparently the relating of these groups to the forms experienced in the past is very effective in mastering serial problems of this nature.

CHAPTER IV

Forward and Backward Associations

1. *The History of the Problem*

Herbart (17) is probably largely responsible for discussion and experimentation in the field of forward and backward association. He stated that if a series of ideas called *a b c d* . . . is perceived with *c* at one instant of time in full consciousness, *b* and *d,* which are somewhat inhibited, as well as *a,* which is more inhibited, unite with *c.* The connection between *b* and *c,* however, is stronger than the connection between *a* and *c.* Similarly the greater the number of intervening members, the weaker is the connection. Ebbinghaus (10) tested this hypothesis experimentally by learning series of nonsense syllables and relearning these series in changed orders, thereby obtaining the time saved due to associations formed in the first learning. These changed orders were constructed by making series composed of every other syllable, every third syllable, every fourth syllable, and every seventh syllable of the original series. If associations were made between remote syllables in the original learning as Herbart suggested, then the derived series should be easier to learn than any new series. Furthermore, if associations are weaker when the syllables in the original learning are more remote, then the derived series composed of every other syllable should be easier to learn than the derived series composed of every third syllable of the original series. This is substantially what Ebbinghaus found, as the short broken line given in Figure 5 shows. (The values of Ebbinghaus' results for saving of work in per cent of the original learning have been doubled. One degree of anticipation equals one degree of remote forward association in reading the graph with respect to Ebbinghaus' figures.) Ebbinghaus likewise obtained results showing the presence of backward association, *i.e.,* associations between *d* and *c,* and *e* and *c,* etc.

Cason (5) worked with nonsense syllables, prose, and poetry and found little evidence for backward association and none for remote forward association. He used the savings method and presented the material so that the subject should perceive only one nonsense syllable or word at a time, and in a fixed order so that skipping and retracing would be hindered. He concludes that Ebbinghaus must attribute his results not to remote association of the Herbartian type, but to specific serial association brought about by mentally placing remote parts of the series in juxtaposition.

Hall (13) recently has reconciled some of the apparently conflicting results by showing that remote association is much more effective after a lapse of time (one week). She suggests that after a series is just learned, the relationships existing between successive members operate to interfere with the development of remote associations but that with a lapse of time the interference diminishes disproportionately to the weakening of the remote association and the latter becomes demonstrable. In the case of Ebbinghaus the lapse of time was twenty-four hours. Cason, however, tested almost immediately. Overlearning, according to Hall, is another complicating factor, whereby the interference becomes greater and remote association less easily shown.

2. *Explanation of Tables and Graphs*

The data treated here include only the first wrong response of a series of wrong responses made in locating any one correct letter. Table IV and Figures 2, 3, and 4 show the average number of errors (first wrong responses) for each of the three mazes, where the errors are of the type obtained by skipping one right letter, two right letters, etc. in the maze. This is referred to as anticipating the 1st, 2nd etc. letters ahead. An example taken from Maze 1 is given. The letters are *J C L A M I L*, etc. The subject presses *J C* and then *A*. The first two responses are correct. The third response, or letter, anticipates the *A* coming after *L*. The subject is thus anticipating the 1st letter ahead, or skipping one right letter. Similarly the subject might have pressed *J C* and then *I*, thus anticipating the 3rd letter ahead, or skipping 3 right letters. The tabulated uncorrected data give the averages of the anticipations of the 1st, 2nd, etc. letters ahead for all points of the maze. Two main difficulties arise in the calculation of these averages. It will be seen that the subject punching *J C* and then *L* may be considered as either making the correct response or anticipating the 5th letter ahead. In the latter case the record will be zero, since the *L* is always recorded as correct response. Furthermore, if the subject punches *J* and then *L* in beginning the maze, it is a question

whether he is anticipating the 1st or 5th letter ahead or perhaps the result is the combined effect of both anticipations. These are called repetition scores. Such scores as well as the zero scores will distort the relation between the frequency of anticipation and the remoteness of the letter. They have therefore been eliminated and the averages of the remaining scores taken. These averages are the corrected values of Table IV and Figures 2, 3, and 4. From inspection of the curves it will be seen that the corrected values give a slightly more regular relationship and agree better when the different mazes are compared.

Table V and Figures 2, 3, and 4 on backward association give the results obtained when the errors are regarded as referring to right letters already passed in the maze. The part *J C L A M I L* is again used for illustrative purposes. The subject presses *J C L A* and then *C;* this is called "an error identical with the 2nd back letter" in the table. Had *J* been punched instead of *C,* an error identical with the 3rd back letter would have been made. The corrected values are obtained by applying the previously mentioned treatment to these backward types of errors.

A further and somewhat laborious type of correction was attempted on Maze 1 to determine if the massing of the errors near the center of the maze due to the delayed learning of that part, and the results of habit interference were responsible for the relationship found in Table IV. Accordingly all points of the maze were given equal value by giving the different kinds of errors made at any point as per cents of the total errors made at that point. Figure 5 presents the data in this form. The table from which Figure 5 was made is given elsewhere (30). Comparison of the uncorrected curve of Figure 2 with the "all scores" curve of Figure 5 shows that the curvilinear relation is the same. Removing the results of habit interference shows conclusively that this factor is not responsible for the curvilinear relation found in Maze 1 between the amount of anticipations and the number of units skipped.

In order to analyze the relation of anticipation and progress in learning, the errors made on the second maze were divided into four sections. Table VI shows the data given as per cents using the per cent method mentioned immediately above for each of the sections. The first section contains all the errors made by the subject on the first trial. Here, as one would expect, there is no relation between the amount of anticipations and the number of units skipped; thereby providing additional evidence that the curvilinear results obtained for the other sections and those given in Table IV and Figure 5 are not directly due to the method of treating the data. The errors made on the second and subsequent trials were divided into the three sections as evenly as possible, and each point of the maze was considered separately to neutralize the effect of the preponderance of errors near the center of the maze. An example is taken from two points in the maze, the 1st point between the 3rd and 4th letters, or *L* and *A,* and the second between the 12th and 13th letters, or *G* and *J.* The letters punched for the different trials are given. Where no letter occurs the correct letter was punched. The letters of the first trial (*e* coming after *L,* and *m* coming after *G*) are put in the first section. There are four errors

		Trials										
Letters		1	2	3	4	5	6	7	8	9	10	11
3	L											
4	A	e	b	m		e	j					
12	G											
13	J	m	a	k	a	a	b	a	k	k		

on the subsequent trials made after *L*. The first two of these are put in the second section, and the other two are put in the third and fourth sections respectively. There are eight errors made after *G* on the second and following trials. The first three, *a, k,* and *a,* are put in the second section. The next three, *a, b,* and *a,* are put in the third section. Since the number of errors is small for any section, single errors sometimes play an excessive rôle. In Table VI, under the column marked 7, the two starred numbers are unduly large because for each section one of the scores used in obtaining the average there given has the value of .50. This is so because at that point in the maze only two errors were made by all the subjects in the second and third sections.

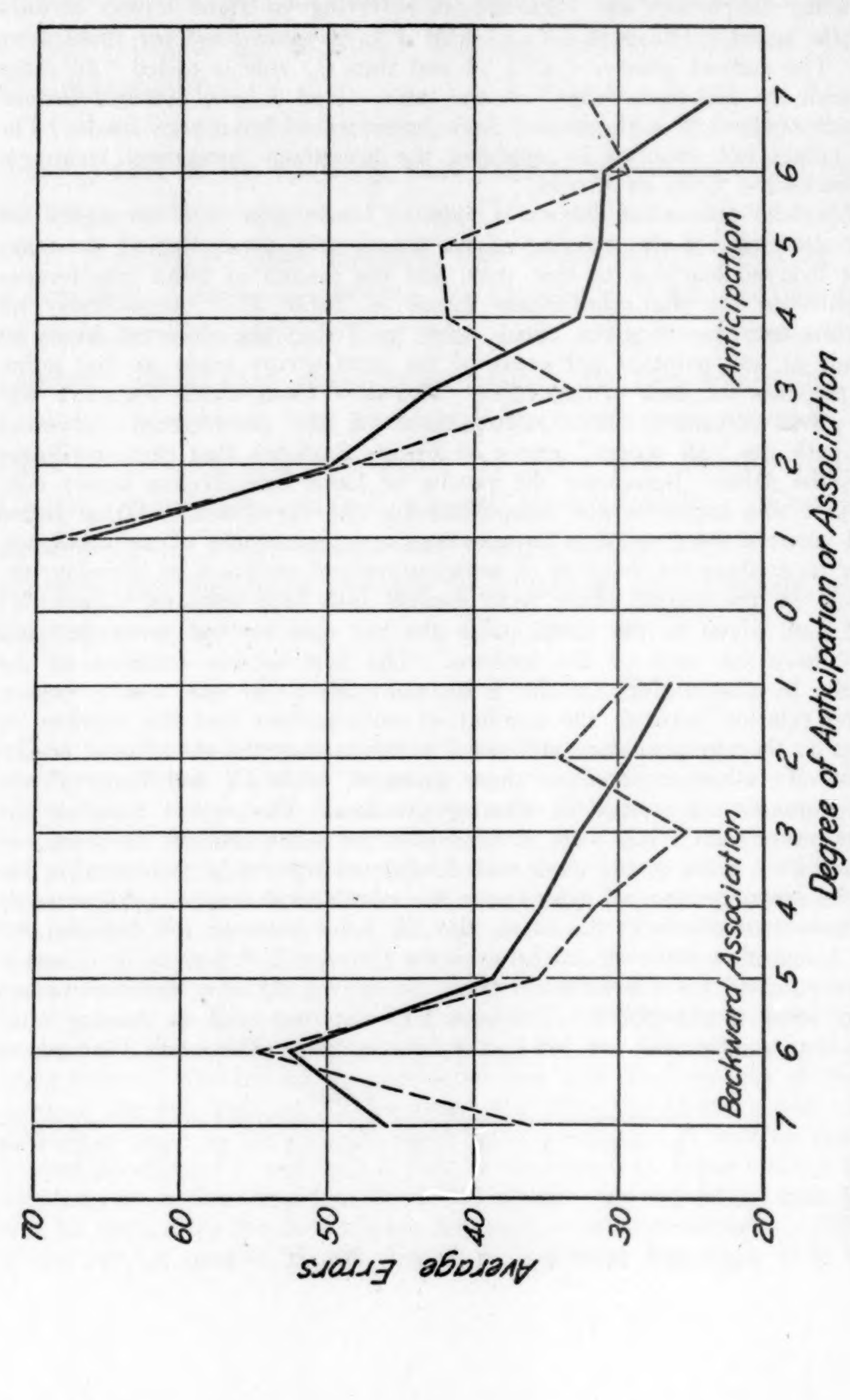
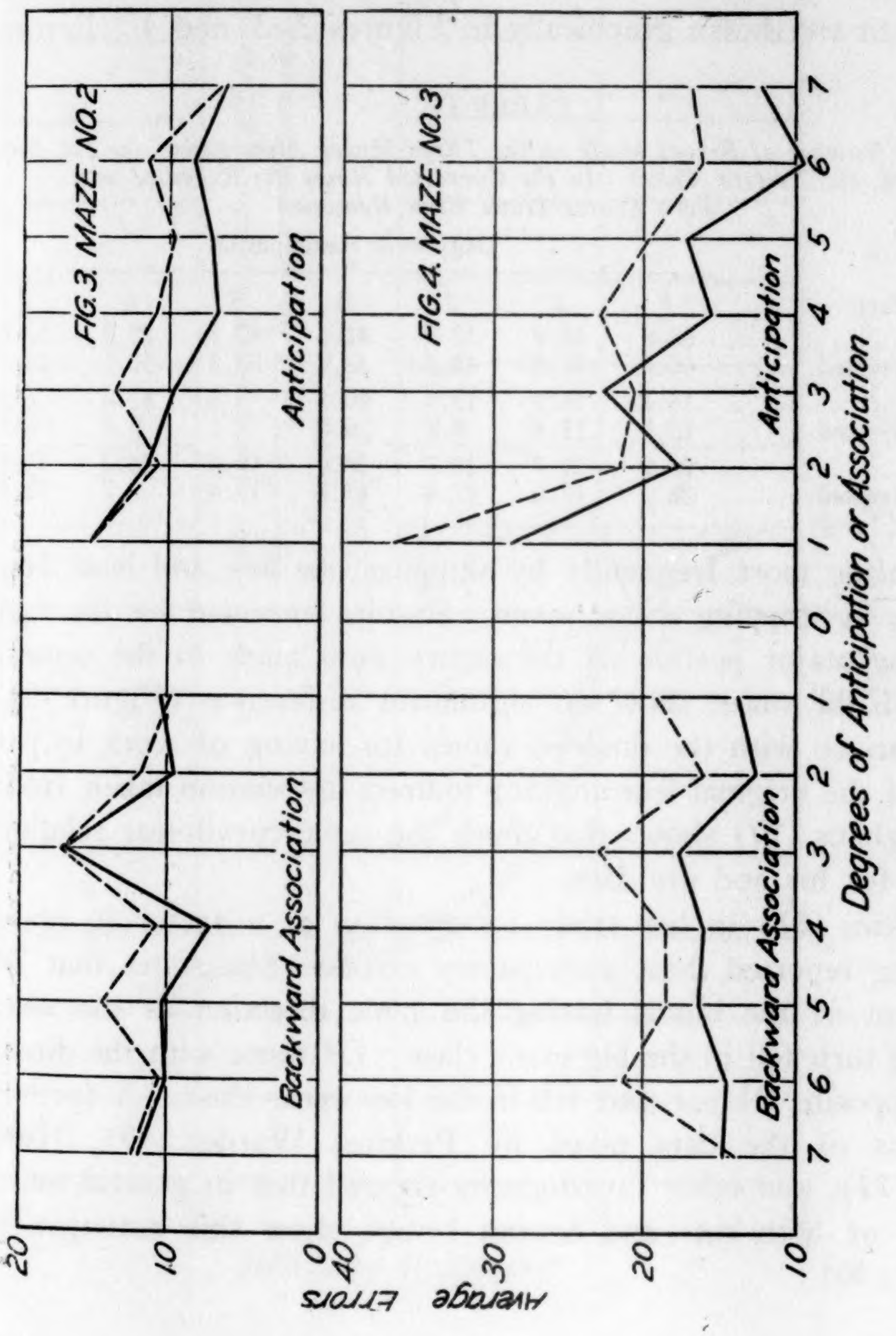


FIG. 2. MAZE NO. 1. ERRORS SHOWING ANTICIPATION AND BACKWARD ASSOCIATION
—— Corrected - - - - Uncorrected

Thus each error has the weight of 50 per cent, and since the other scores are not numerous, weights them significantly. The "total" column is obtained by adding up the rows, and gives in a general way the per cent of errors showing anticipation as compared with those not showing it. The last column (ratio) shows the sum of the results of the columns 5, 6, and 7 divided by the sum of the results of columns 1, 2, and 3.

Table VII shows the results in per cent of errors for the first maze at some of the different points, or letters, in the maze. The purpose of this table is to show that the anticipations for the individual points have much the same relation as is shown by the composite values of Table IV.



ERRORS SHOWING ANTICIPATION AND BACKWARD ASSOCIATION — Corrected - - - - Uncorrected

3. *Results and Interpretation*

Employing a different method from those mentioned in the section on the history of the problem, I find that in learning a letter maze there was a tendency to anticipate letters which occurred further on in the maze. The strength of this tendency seemed to vary with the remoteness of the anticipated letter.

Table IV shows the results obtained on each of the three mazes. The data are shown graphically in Figures 2, 3, and 4. Errors

TABLE IV

Average Number of Errors Made on the Three Mazes Anticipating the 1st, 2nd, 3rd, etc. Letters Ahead. In the Corrected Rows the Repeated and Zero Scores Have Been Removed

	Degrees of Anticipation						
Maze	1	2	3	4	5	6	7
I	68.8	48.9	33.0	41.5	42.3	29.5	32.0
I corrected	66.7	49.8	43.3	32.9	31.3	31.1	24.7
II	15.2	10.9	13.9	10.7	9.6	11.4	6.2
II corrected	15.1	11.4	9.8	6.8	7.1	8.4	6.4
III	36.9	21.7	20.7	23.0	19.6	16.2	16.8
III corrected	28.6	17.6	22.8	15.5	17.4	9.7	12.4

were made most frequently by skipping one key and least frequently by skipping six or seven. Results corrected for the fact that the major portion of the errors were made in the central part of the maze show no significant difference (Figure 5). Comparison with the doubled values for saving of work in per cent of the original learning for indirect association taken from Ebbinghaus (10) shows that much the same curvilinear relation exists for his and my data.

Perkins (37) in her study of direction as a factor in maze learning reported these anticipatory errors. She states that 78 per cent of the blinds having the same direction as the next correct turn fell in the big error class. Of those with the direction opposite, 81 per cent fell in the low error class. A further analysis of the data given by Perkins, Warden (46), Husband (23), and other investigators showed that in general maze errors of both rats and human beings show this anticipation factor (30).

The problem for the subject in learning a letter maze or sequence of syllables may be roughly divided into two parts. In the first place the proper letters and syllables must be learned as such and in the second place they must be put in the proper

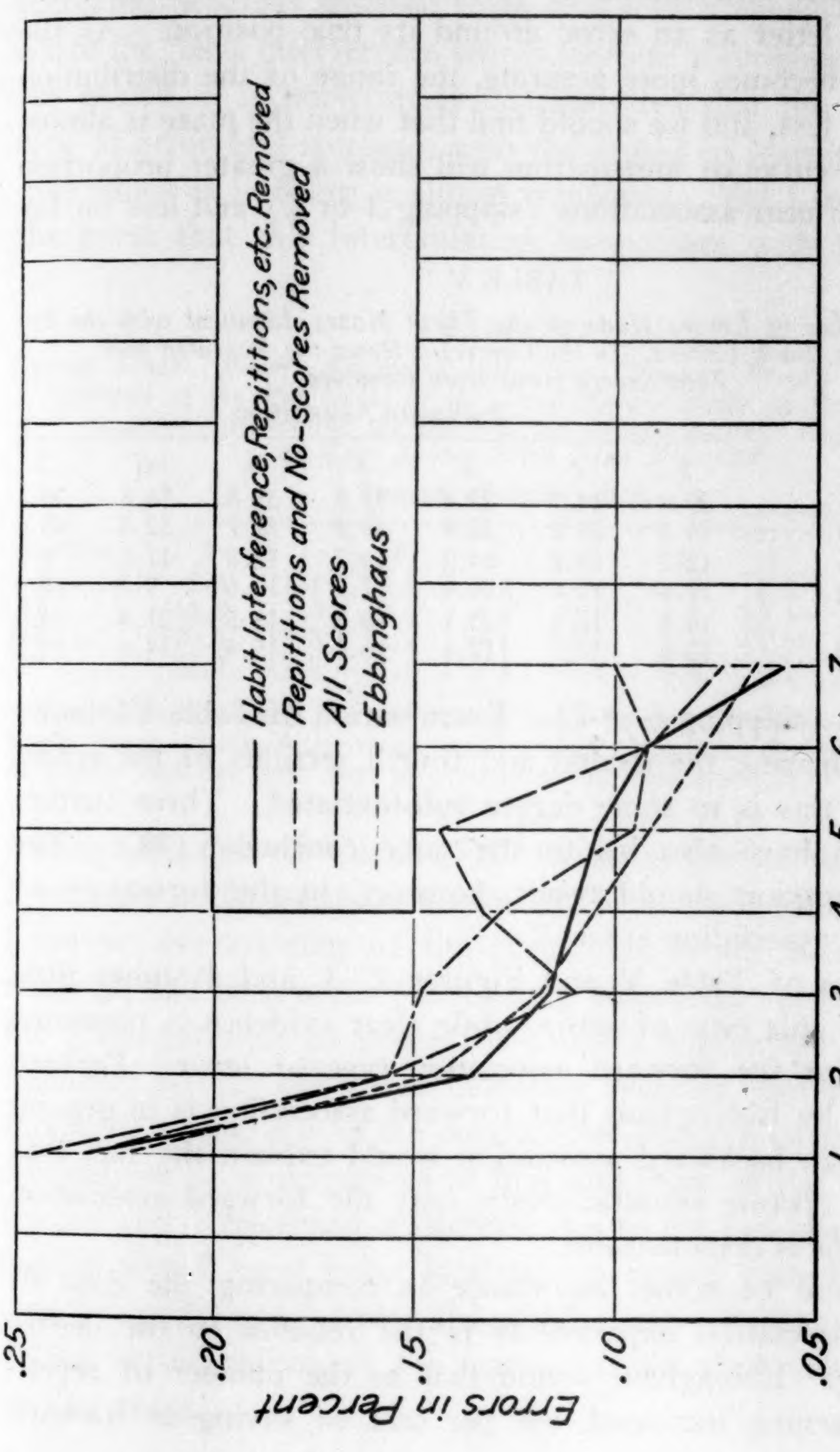


FIG. 5. 1st MAZE. FORWARD ASSOCIATION
Errors in Percent of Errors for a Given Letter

order. It would seem that the first part of the problem is usually accomplished first. If the letters are thus learned and assigned to the first part of the maze (near the beginning), and the last part of the maze (near the end) or the middle, we should expect these indefinite localizations to result in a symmetrical distribution of the letter as an error around its true position. As the localization becomes more accurate, the range of the distribution will become less, and we should find that when the maze is almost learned, the curve of anticipation will show a greater proportion of errors on near associations (skipping 1 or 2) and less on far

TABLE V

Average Number of Errors Made on the Three Mazes, Identical with the 1st, 2nd, etc. Back Letters. In the Corrected Rows the Repeated and Zero Scores Have Been Removed

	Backward Association						
Maze	1	2	3	4	5	6	7
I	29.4	34.1	25.4	31.9	35.6	54.8	36.1
I corrected.......	26.3	29.2	32.8	35.2	38.7	52.4	45.6
II	12.2	10.2	14.2	10.7	16.8	11.6	9.7
II corrected.......	11.6	10.0	10.4	7.2	16.6	9.5	10.4
III	19.0	16.1	23.1	18.5	18.5	21.4	13.9
III corrected.......	13.6	12.7	17.6	16.0	16.4	14.6	14.5

associations (skipping 6 or 7). Examination of Table VI shows that in comparing the second and fourth sections of the errors of Maze 2 this is to some degree substantiated. Three further experiments have also led to the same conclusion (**29**). The above assumption should result, however, in the formation of " backward association errors."

Inspection of Table V and Figures 2, 3, and 4 shows little evidence of this type of error, while clear evidence is presented elsewhere for the forward association type of error. Perhaps the finding by Ebbinghaus that forward association is in general stronger than backward association would explain the fact that when both operate simultaneously, only the forward association type of error is demonstrable.

A question of some importance in comparing the data of forward association experiments is the relation to the degree of learning. Ebbinghaus found that as the number of repetitions in learning increased, the per cent of saving in forward

association (skipping one syllable) decreased in comparison with the saving in normal association (original order). A study of the totals as well as the separate results in Table VI reveals that from divisions one to two, and two to three, the anticipation increased, whereas between three and four a decrease is shown. Since the habit interference scores increase throughout the learning period, it is not entirely demonstrated that the anticipation type of error first increases with the degree of learning and then diminishes as learning is almost completed. Yet I might hazard the guess that this interpretation harmonizes with the data of

TABLE VI

Second Maze. Errors Separated Into Four Groups. Errors Given as the Average of the Per Cents of the Total Errors Made on the Different Letters Anticipating the 1st, 2nd, etc. Letters Ahead. Repetition and Zero Scores Have Been Removed

	Degrees of Anticipation								
Section	1	2	3	4	5	6	7	Total	Ratio
I......	5.8	2.4	3.9	2.6	7.4	11.0	8.5	41.6	2.225
II......	16.6	12.4	9.6	9.4	7.8	8.5	12.1*	70.3	.577
III......	20.1	13.0	12.8	10.1	10.6	4.5	11.9*	77.1	.459
IV......	18.7	17.8	11.0	9.4	3.5	6.4	5.1	71.9	.316

The numbers starred (*) are unduly large because of chance weighting of single scores. Half of the value would probably represent the conditions more accurately and has been used in computing the total and ratio.

Ebbinghaus and of Cason (5). Cason employed prose, where apparently no forward association can be brought to light. Here, however, overlearning of the parts, due to the nature of the material, had been accomplished long before the students studied the given example of prose for Cason's experiment. Thus in localizing serially the letters, nonsense syllables, and words there should be an increase in the comparative strength of the forward associations or anticipations at first and then, as the material is learned and overlearned, a decrease due to the fact that emphasis is now placed upon exact localizations rather than the general type "near the end," "near the middle," etc. A complete record of the verbalizations of the learner would shed valuable light on this point.

Table VII shows that the tendency found for the pooled results of Maze 1 is also evident from the results of anticipating any one letter or point in the maze.

The relation between the anticipation of one letter ahead (skipping) and the intelligence-test score is given in Table XIII.

TABLE VII

First Maze. Results Show How Single Letters Were Anticipated. Letters Having Repetitions and Zero Scores Are Not Given. Errors Are Given in Per Cent of Total Errors for Different Letters

	Degrees of Anticipation						
Letter	1	2	3	4	5	6	7
A......	42.2	29.3	28.4	24.3	25.2	15.6	17.1
E......	26.1	24.7	15.0	11.9	2.5	0.8	
E......	22.6	21.5	9.0	6.3	10.6	9.2	7.6
J......	10.5	8.5	16.0	11.0	6.0	12.3	7.2
K......	13.8	5.1	24.4	8.9	4.2	5.9	6.6
M	14.9	29.0	22.5	10.3	10.6	18.1	6.4
M	56.4	24.7	12.5				

Correlations between skipping and the various measures of maze performance are given in Table XV. There is no significant relation shown. The values for skipping were obtained by dividing the cases of one right letter being skipped by the total number of errors.

4. *Conclusions*

It seems possible to draw three conclusions from the data just presented.

1. Anticipation of letters, or "forward association," occurs under normal conditions of learning.

2. As the learning progresses, the placing of letters becomes more exact, and more errors of anticipation are made on near letters than on far letters.

3. During the learning process the total anticipation in per-cent of errors increases and then decreases as a perfect performance is attained. Judging from the results of Ebbinghaus and Cason, it should decrease still further with overlearning.

CHAPTER V

Habit Interference

1. *Introduction*

The term habit interference has been used mainly in connection with maze performances and motor skills. The essential problem is: if one habit is acquired, how much does it interfere with the simultaneous or successive learning of another habit? The term negative transfer might be a better one. Habit interference and transfer of training are the two aspects of the influence of any given unit of behavior upon any simultaneous or subsequent behavior. In the literature on association the terms associative inhibition (Mueller and Schumann) and intended failure reaction (Ach) refer to much the same sort of thing.

2. *The History of the Problem*

Hunter (21) has reviewed the literature on habit interference. In his own experiments he trained rats in a discrimination habit and then reversed the discrimination. The animals took twice as long to learn the new habit. The learning curve showed that at first they chose the wrong box (the one that had been right formerly) more than a chance number of times. Graphing successive tenths of the learning process according to the Vincent method, Hunter found that the interference took place in the first half of the learning. Similar results have been obtained in multiple choice experiments (41) where the animal had to break up the previous habit or ideation (as wished) before learning the second problem. Experiments with human beings more rarely show this type of problem set or attitude interference, since the subject tacitly assumes that a new problem is given him, or is instructed that such is the case. There are, however, cases of specific interferences in using mazes that resemble each other. Perkins (37) hints at this type of difficulty in her classification

of the errors made on a maze resembling one previously learned. The errors of this type were relatively few, however. Some of the errors which she classed as " anticipatory " (see preceding chapter) were brought about when the true path was identical for three units in two different parts of the maze. The subjects erred in the first instance by making a turn that would have been right had it come at the end of the second series of the three identical units. This might be looked upon as habit interference. Scott (42) also suggests that the learning of certain mazes interfered with the learning of others due to certain similar and dissimilar parts. Webb (49), although finding no habit interference for total trials and errors between two mazes, states that certain culs-de-sac were learned with more difficulty after learning the first maze than without previous training. Wiltbank (50) in a study of transfer of training in rat maze learning showed that certain culs-de-sac were eliminated with great difficulty because of training on a previous maze.

The contrasting effects of instruction and specific association are brought out by Ach's (1) method of associative equivalents. Two nonsense syllables are associated a certain number of times and then the subject is requested to rhyme or invert one of them when it is given. The subject may carry out the instructions or give the associated syllable in spite of the instructions, in which latter case the response is called an intended failure response. Ach hoped to measure the strength of the association by the number of repetitions required to withstand contrary instruction. Lewin (28) carried out an experiment using the same method and showed the extreme importance of the instruction as compared with the association factor. In examining any learning situation for examples of interference (habit interference or associative inhibition), therefore, it is of paramount importance to discover the self-instruction or set which the subject has taken. It is possible to look upon organization or grouping of the material as equivalent to a self-instruction. In this case little or no interference or associative inhibition should be shown if, as Lewin showed, interference may be hindered by appropriate instruction.

Bergström (3) and Brown (4) have shown the presence of interfering associations and habits in card sorting experiments. Kline (25) in a study of the effect of previously formed associations on the further association of one of the members has shown that the interference increases to a certain extent with the strength of the first association. If the first association becomes very strong, however, its interfering effect is decreased.

Mueller and Pilzecker (32) and Mueller and Schumann (33) originally showed the inhibiting effect of one association upon the formation of another and formulated the law of associative inhibition that " if *a* is already connected with *b*, then it is difficult to connect it with *k*; *b* gets in the way." (Quoted from Kline.)

3. *Explanation of Tables*

Table VIII shows the relation between habit interference and the kinds of grouping employed. The introspective reports of the subjects were analyzed and the letters classified as occurring in certain types of groups. The groups used for purposes of classification are given below.

1. Words.
2. Defective words.
3. Sound combinations.
4. Abbreviations or initials.
5. Position on keys.
6. Unidentified.
7. Letters standing at the end of any of the above groups.
8. Letters standing alone.
9. Omitted in the report.
10. Groups which were so formed that interference was aided.

The above groups were arbitrarily ranked in the order in which they are given. I judged from the performance of the subjects in the maze that the importance and strength of the groupings corresponded to this ranking. This is by no means necessarily so.

Habit interference may occur when two parts of a maze are identical in form and the parts following each are different. In all three mazes there were repeated letters which constituted identical parts followed by other letters that were different. An example taken from the first maze is *E G A* as compared with *L G J*. *G* is the identical letter, and *A* and *J* are the different letters following. Subjects would show habit interference if they punched *E G J* and *L G A* with a frequency greater than that expected by chance.

Habit interference may operate so that (1) there is mutual interference (*E G J* and *L G A* are punched), or (2) there is interference with only one of the letters. (Either *E G J* and *L G J* or *E G A* and *L G A* are punched.) For purposes of anlaysis three arbitrary classes of interference were chosen. Class C included only those cases where one of the members showed interference of three, four, or more units and the other member 0 or 1. Class B contained, excluding Class C, those cases where at least a difference of 2

existed between the members, and the interference with one member was twice as large as that with the other. Class A included those cases where both members showed interference, and the interference with one of the members was at least 2 units. Two examples of each of the three classes are given below.

	1st and 2nd Members		1st and 2nd Members	
A	EGJ, EGJ	LGA	EGJ, EGJ, EGJ, EGJ,	LGA, LGA, LGA
	2	1	4	3
B	EGJ, EGJ		EGJ, EGJ, EGJ, EGJ, EGJ,	LGA, LGA
	2	0	5	2
C	EGJ, EGJ, EGJ		EGJ, EGJ, EGJ, EGJ,	LGA
	3	0	4	1

It was necessary to correct the results for the number of opportunities for responses showing interference. Again, the fact that certain parts of the maze were learned more quickly than others was a complicating factor. If thirty errors were made after *L G* and three of those were of the *L G A,* or habit interference type, it would have been idle to attribute them to habit interference, since the probabilities would have been in favor of the subject's making that many of this type by chance alone. If only two errors were made after *E G* and neither was of the habit interference type, it would have been especially absurd to say that a case coming under Class C was present. Therefore the two members were roughly equalized by deducting one unit of interference from the larger member for every 9 errors by which it exceeded the smaller one. In the above-mentioned case the 28 errors by which the two members differ completely wiped out the apparent ratio of 3 to 0 units of interference, and the case was not considered as one of habit interference at all.

Class A included cases of mutual interference, Class C those of interference in one direction only, and Class B was an intermediate category. Those cases where one member showed one unit interference and the other 1 or 0 units were not counted. Chance would probably have accounted for all such cases if not for some of the others.

There are three ways in which the classification of groupings may be related to any case of interference; (x) the interfering member may rank higher than the member interfered with, (y) the two may be equal in rank, (z) the interfered-with member may be of higher rank than the interfering member. Accordingly the relations between the classifications of interference A, B, and C and the relative ranking of the members x, y, and z are shown in Table VIII. Although Class A represented mutual interference, there were always slight differences in the amount of interference, so that the xyz scale could be applied. Since the task of assigning grouping ranks to the members of the habit interference cases was not always easy and prejudice might have influenced the result decidedly, the ranks were assigned in ignorance of the direction of the interference, and the xyz classification was made later.

In Table VIII the row *a* refers to the number (in per cent) of the cases for each of the classifications A, B, and C. *n* gives the number of cases of habit interference for each of the divisions. The divisions I, II, and III refer to the letters of the 1st, 2nd, and 3rd mazes respectively which occur twice, or else three times with the same letter following two times. IV refers to the letters in the 3rd maze occurring more than three times.

Table IX shows the percentage of letters falling into each rank or grouping according to the introspective reports for the three mazes. Column *a* gives

cases of habit interference where the member is interfered with; column *b* where the member interferes; and column *c* includes all the letters of the introspective reports without regard to habit interference. In order to show the general trend of organization or the making of more verbal groupings the total of the first four groups is given in the bottom row. However, the results given in columns *a* and *b* and the results given in column *c* are not strictly comparable. Rank or grouping 7 (letters standing at the end of a group) was not obtained for the total cases, because it had little significance there and would have concealed the true grouping. Rank 7 was used with the habit interfering cases, since there is a decided break between the letter standing at the end of a group and the next letter, whether that group is a word grouping or position grouping. The cases coming under rank 7 were therefore discarded in the case of columns *a* and *b* and the per cents given in terms of the remaining totals. This procedure has a tendency to overemphasize ranks 8 and 9 at the expense of the others in these columns.

The effect of interference in the learning of the second maze is shown in Table X. The errors were separated, according to the method outlined in section 2, Chapter IV, into sections corresponding to the different degrees of progress in learning the maze. The errors showing the influence of the first maze and the second maze upon the second maze are given in per cents of the total errors for each section. A subject rarely repeated a letter that had just been the correct response. This and the fact that one of the other twelve permissible letters would be the next correct response gives eleven possible different errors. Therefore on a chance basis the subject would make responses showing 9 per cent interference. All letters which occurred twice in the first maze will show by chance an interference in the second maze double the number of times that any letter which occurred only once in the first maze will show. Therefore the habit interference errors of the second maze must be divided by the number of times the letter (identical point) occurred in the first maze to correct for this difficulty. Similarly in showing habit interference of one maze upon itself the habit interference errors must be divided by the number of times (minus one) the letter (identical point) occurred in the maze. A further correction was made for the unequal effect this dividing process had. The complete formula by which the results in Table X were computed is

$$\frac{\Sigma\,E}{\Sigma\,[(n-1)\cdot T_E]-[(n-2)\cdot E]},$$

where n equals the number of times a given right letter occurred in the maze; T_E the total errors for each point where habit interference was possible; E the errors at each point showing habit interference. The summing up of these points where habit interference was possible gave the score for the whole maze. The values in Table X were further corrected by excluding cases where Mazes 1 on 2 and 2 on 2 showed common interference and cases where interference and skipping coincided.

In Table X the columns give the errors for the different sections, and the first row shows the effect of Maze 1 on Maze 2, the second row the effect of Maze 2 on itself.

4. *Results and Interpretation*

Table XV in Chapter VIII gives the relation of the habit interference scores made by the subjects on the first maze to

the total time (r .09), errors (r .09), and trials (r .21). The habit interference scores were computed by counting up the number of errors showing habit interference and dividing each type of error (see explanation of tables in Chapter VI) by the number of times (minus one) that the preceding right letter occurred in the maze. The total score for each subject was

TABLE VIII

Interference Divided Into Three Types, A, B, and C. The Relation of the Groups in Any Case of Interference is Given as x, y, and z. The Figures Are Given as Per Cents of Any Column

	A	B	C	A	B	C	A	B	C	A	B	C
x	44	33	11	28	14	23	30	37	28	32	35	24
y	22	14	30	43	18	12	10	19	12	18	21	35
z	33	52	58	28	68	65	60	43	59	49	43	41
a	24	28	48	13	54	33	13	47	40	17	41	42
n		74			53			79			294	
		I			II			III			IV	

a gives the per cent of cases for the A, B, and C classifications. n gives the number of cases for each division. I, II, III refer to the letters of the 1st, 2nd, and 3rd mazes which occur twice or three times with the same letter following two times. IV refers to the letters occurring in the 3rd maze more than three times.

divided by the number of all kinds of errors. There is no relation shown between this method of measuring habit interference and performance in the maze.

When two associations are learned at the same time, one may interfere with the other, or they may both interfere with each other. Table VIII shows that about 20 per cent of the cases of habit interference fall in the A columns showing mutual interference. The other cases fall about equally in columns B and C showing in the first case that there is a tendency for only one of the terms to be interfered with, and in the second case that only one of the terms actually shows interference.

If interference takes place so that one of the terms shows it and the other does not, examination of the types of organization might reveal a reason for this difference. Table IX gives a summary of the different types of groupings in which the letters leading up to the interference were found. Column *a* shows the types of groupings for the interfered-with portion, and column *b* the types of groupings for the interfering portion. The totals for the first four groupings given at the bottom of

the table enable one to see that the so-called interfering groupings (part not showing interference) were more verbal in character than the interfered-with groupings (part showing interference). In general the total cases regardless of interference showed more verbal groupings. It would seem then as if a verbal type of grouping (and grouping to any extent) was less susceptible

TABLE IX

Percentage of Letters in Each Kind of Grouping According to the Introspective Reports. Total Cases (c) Are Given as Well as Cases of Habit Interference for the Interfering (b) and Affected (a) Letters

	I			II			III		
	a	b	c	a	b	c	a	b	c
1. Words	0.0	12.1	14.8	15.8	35.7	39.6	15.9	29.4	36.5
2. Defective words	5.9	12.1	11.3	2.4	16.7	13.5	25.4	26.5	19.5
3. Sounds	5.9	6.9	7.7	0.0	4.8	3.8	7.9	5.9	16.4
4. Abbrev.	5.9	8.6	12.4	0.0	16.7	6.6	1.6	1.5	4.8
5. Position	21.6	10.3	16.7	26.3	16.7	13.9	11.1	10.3	5.7
6. Unidentif.	29.4	29.3	27.0	31.6	4.8	15.0	23.8	20.6	11.5
7. Alone	19.6	13.8	6.5	15.8	0.0	5.7	14.3	5.9	4.6
8. Dropped	11.8	6.9	3.5	7.9	4.8	1.8	0.0	0.0	0.3
Total for first four	17.6	39.7	46.2	18.4	73.8	63.6	50.8	63.2	77.3

to interference. For the first maze there were 200 cases where interference might have occurred. Of these, 126 cases showed no noticeable interference.

Further proof of the importance of organization in the direction of interference is given in Table VIII, where row *z* represents the interfering group as having a higher rank of organization than the interfered-with group. For columns B and C, where the interference operates in one direction, the per cents in row *z* are higher than for either of the other rows. *Therefore the more highly organized a grouping is, the less susceptible to interference it proves to be, and the more likely it is to cause interference in a less well organized grouping, within certain limits.* The standard of organization in the cases showing no interference was higher than in the cases with interference. This might be taken to agree with Kline's results whereby the interference was less when the former association was extremely strong (well organized). It is important to remember that the organization of letters must not be thought of primarily as a strength of

association between the individual letters but as an instruction (see Lewin's [28] experiment) to the subject favoring certain responses rather than others.

In order to determine the influence of habit interference from the preceding maze and of the second maze on itself, this second maze was analyzed according to the four-section treatment described under remote association. The effect of Maze 1 on Maze 2 was much the same throughout and just slightly more

TABLE X

Second Maze. Shows Interference by the First Maze Upon the Four Sections of Errors of the Second Maze as Well as Habit Interference of the Second Maze on Itself. Errors Are in Per Cents of the Total Errors for Each Section

Maze	I	II	III	IV
I on II......	.140	.102	.117	.161
II on II......	.101	.133	.190	.216

Chance interference .090.

than a chance effect. On the other hand interference of the second maze with itself increased steadily with mastery of the maze. These results are given in Table X.

A correlation of .39 exists between the habit interference scores and the skipping scores. Both the habit interference and skipping effects, however, are still shown when the other factor is removed, so that they may be regarded as independent to some extent at least.

5. *Conclusions*

The organization or grouping of material prevents the development of habit interference and determines the direction of this interference. This points to the conclusion that when foreign languages, such as French and Spanish, are taught simultaneously or even successively, the whole or grouping method of instruction should be preferable. Thus a student would learn a group of words as associated with a definite meaning, rather than building up that meaning from the individual meanings of the words.

There is a direct relation between the judged degree of organization of the group and its susceptibility to interference. Verbal groups which may be looked upon as highly organized show little interference. Unidentified groups, on the contrary, show interference.

CHAPTER VI

Variability of Response

Cason and Cason (6) have found insignificant correlations between the individuality of response, as measured by the Kent-Rosanoff test, and learning scores. A correlation of $.27 \pm .09$ was obtained between speed of learning and individuality and one of $.18 \pm .09$ between accuracy of learning and individuality. By individuality was meant the variation of the responses from the average. Subjects showing variability of behavior might be expected to form and change groupings more readily, and thus build complexes which would be easy to remember. Furthermore, the variable subject should not stereotype his errors, and this too would lead to a more successful performance. Two assumed measures of this trait were taken. The first measure attempted to indicate the degree of variability in grouping. Did the subject change the association of the specific letters, trying them first with the letters ahead and then with the letters behind? Since the time between the striking of any right letter and the striking of the next right letter was recorded, it was an easy matter to determine whether a specific letter was grouped with the ones preceding it or following it. The procedure of calculating this measure called "time change" was involved and is not given here in view of the unimportant relationships shown in Table XV. It is apparent that this kind of variability is immaterial as far as the trial criterion of learning is concerned. The other measure, called "letter change," was procured by scoring one point for every change in the errors made on successive trials at the same point in the maze. Thus if the subject pressed the letter *A* after pressing the right letters *J* and *C* of the first maze on one trial and pressed the letter *D* on the next trial at this same place, a score of 1 was given. If on the third trial he pressed *B*, the score was 2. But if *D* had been pressed again on the third trial, the score would have remained 1, since

there is no change of letter when *D* is made as an error on successive trials. This total score was then divided by the number of chances to score. The correlations of this letter change with total time, errors, and trials are not significant (Table XV). The correlation of time change with letter change is .25, showing that either the same thing is not measured (the same kind of variability), or else that the derivation of the measures is faulty. I judge that both interpretations are correct. In spite of the negative results of this aspect of the problem I feel that further investigations of the relationship of variability of response to learning should yield positive results, on the general assumption that variability of response itself is evidence of learning.

CHAPTER VII

Inefficient Types of Response

While a great many different responses of the subject are of doubtful aid in learning a maze, certain responses, as Hamilton (14, 15) has shown, seem particularly inappropriate and may be considered a sign of inability to cope with the situation. Such responses are repetitions of errors. Disregard of instructions and relapses (errorless trials and then errors) might also be considered inefficient.

Hamilton experimented with different animals and human beings in a room containing three locked and one unlocked exits. The problem of the animal was the discovery of the unlocked exit. The performance of the lower animals was characterized by the fact that they would try the same door over several times, although one try should have been enough to show that the door was fastened. Hamilton listed several types of repetitions. Three of these types were as follows: (1) the animal tries a door, goes away, and then comes back and tries the same door again; (2) the animal tries the same door three or more times but always tries another door in between times; (3) the animal tries the same door again immediately without trying any other door. Hamilton showed that in general the lower the animal or human being stands on the scale of development, the greater the proportion of second and third types of repetition it shows. He concluded quite properly that the immediate repetition is a more inefficient type of response than the ordinary repetition. Table XI presents the correlations between these three types of repetitions and the total keys pressed and number of trials from the data of the present experiments. In order to equalize the greater chances for repetitions occurring when a larger number of keys were punched, partial correlations are given with the total keys pressed kept constant. Strangely enough the correlations show just the reverse relation to that assumed from Ham-

ilton's work between the types of repetition and the excellence of performance. In all three mazes the subjects who made the largest number of immediate repetitions tended to do best in learning the maze as judged by the trial criterion. A check on the rather doubtful procedure of partial correlation was made by individually dividing the values for the types of repetitions by the total keys pressed and correlating the quotients with the

TABLE XI

Correlations Between Measures of Inefficient Responses and Trials and Total Keys Pressed

Maze	Measure	Repetitions	Repetitions 3 Times	Repetitions Immediately	Letters below M
I	Total keys pressed..........	.38	.52	.37	.43
	Trials......................	.50	.43	.26	.13
	Partial r with total keys pressed constant..........	.35	.05	–.05	–.35
II	Total keys pressed..........	.93	.56	.59	.55
	Trials......................	.73	.39	.35	.36
	Partial r with total keys pressed constant..........	.02	–.07	–.20	–.11
	Check computation.........	.33	.09	–.20	
III	Total keys pressed..........	.88	.60	.44	.64
	Trials......................	.87	.49	.31	.53
	Partial r with total keys pressed constant..........	.35	–.17	–.25	–.17

number of trials. This was done only for the second maze. The actual figures vary, but the tendency remains the same as shown in Table XI.

The subjects who disregarded the instructions and punched letters which were certain to be errors tended to do worse than those who punched fewer of these letters below M. Partial correlations of the relapses or lapses show that the better subject learned the maze without several previous perfect trials. (Table XV.)

Evidently this peculiar relation of the repetitions to the excellency of performance needs further investigation. It is possibly a function of the type of instruction given the subject.

CHAPTER VIII

MISCELLANEOUS RESPONSES

1. *Intelligence-Test Scores and Maze Performance*

Scott (42), training a large number of subjects in maze performance, found that in general the subjects who did well on the scholastic aptitude test also did well in maze performance. Koch (26), Warden (45), and Hunter (20) have also reported relationships between maze performance and intelligence tests.

It might be expected that there would be a high relationship between a test of learning and a test of general information and ability such as the Ohio State University intelligence or prognosis test. This is not shown by the correlations ranging about .50 given in Table XII between the scores on the mazes and

TABLE XII

Correlations of the Ohio State University Intelligence Test Scores With Scores Obtained on the Three Mazes

Intelligence Test and	I r	II r	III r
Total time	−.44	−.59	−.59
Total keys pressed	−.30	−.45	−.46
Errors	−.36	−.53	−.44
Trials	−.50	−.55	−.52
Sounds and words	.49	.34	.13

the above test. Intelligence has sometimes been assumed to be a capacity for quick adjustment and immediate interpretation of the new in terms of familiar experience (see Chapter III). From this standpoint the performance on the first maze should have shown the greatest scattering of scores (which it did in trials) and have correlated most highly with any test of intelligence (which it did not do). The comparison of intelligence scores and other criteria with successive maze performances would undoubtedly be an interesting study. Do those individuals show most intelligent behavior who can handle the situation well the first time? This is one type of learning capacity. Or do those

other individuals who perfect themselves in a situation gradually show the most intelligent behavior? Do we find the same persons heading the group in both instances? This problem leads directly to a consideration of the effect of training on individual differences and points to the difficulty of determining the reliability of tests.

Further correlations (Table XIII) with special measures of the first maze show nothing of importance. From Hamilton's

TABLE XIII

Correlations and Partial Correlations of the Ohio State University Intelligence Test Scores With Special Scores on Maze I

Intelligence Test and	r	$r_{12.3}$	Constant
Pauses	−.40	.00	Total time
Lapses	−.45	−.04	Trials
Habit interference	−.12		
Skipping	−.31		
Letter change	−.14		
Time change	−.10		
Repetitions	−.43	−.36	Total keys pressed
Repetitions three times	−.33	−.20	" " "
Repetitions immediately	−.09	.02	" " "
Letters below M	−.19	−.07	" " "

work one might infer that the less intelligent person would make relatively more immediate than simple repetitions. Therefore the positive partial correlations, when holding the total keys pressed constant, should be highest for single repetitions, less for letters repeated more than once, and least for the immediate repetitions. This is not substantiated by the results given in Table XIII (compare with results given in Chapter VII). Another factor complicates the interpretation. Certain subjects proceeded methodically, punching letters alphabetically or in special orders. These subjects seldom made repetitions. Possibly if a measure of this order tendency had been procured, it would have been shown to be responsible for the repetition correlations. The ease of specific negative conditioning is to some extent a measure of intelligent behavior in animals. The number of repetitions made by a subject is thus the number of times reinforcement is needed for conditioning. Do we have here specific negative habits formed or a general habit (alphabetical method or row method of punching keys) which determines

our responses to the particular keys? Should we say that the person with general habits shows more intelligent behavior than the person with specific habits?

2. *Typing Ability*

Some of the subjects were very familiar with the keyboard of a typewriter, while others were not. This factor might very well have influenced the results. No appreciable relation

TABLE XIV

Correlation Between Speed of Punching or Typing and Different Measures

Speed of Typing and	I r	II r	III r
Total time	–.25	–.36	–.25
Total keys pressed.	–.20	–.25	–.08
Errors	–.18	–.24	–.09
Trials	–.11	–.06	–.05
Letters below M.	–.23	–.29	–.45
Partial r of letters below M, total keys pressed constant	–.16	–.19	–.52

(Table XIV) was found to exist between the speed of typing and the scores on the maze. Subjects not at home on the typewriter should have found it difficult to avoid punching letters below M. This seemed true to a slight extent and might have been a contributing cause to the relationships found between punching letters below M and the other measures.

3. *Pauses*

Usually after the subject had pressed a right letter, he waited before pressing another key. At least two types of thought process went on in this interval. (1) The subject rehearsed the previous right letters before adding on the new right letter. Some subjects did this verbally and aloud; others moved their fingers over the keyboard; lip movement was frequent in others. (2) Or else the subject endeavored to locate the next right key by going through a verbal trial-and-error process to narrow down the choice.

I thought that this implicit trial and error should, as a thinking method, be superior to explicit trial and error, or actually

hitting the keys. I thought that a measure of these waits or pauses might give a measure of the thinking processes of the subject. The correlation between the total time and the pauses, measured as time between any right letter and the first wrong letter, is so great, however, that the pauses appear to be a function of the total time and therefore not related to anything by their own right. The partial correlation of .00 with intelligence-test scores shows this (Table XIII).

There is a complicating factor in the interpretation of the pause results. In the last trials there were few errors made,

TABLE XV

Correlations Between Various Measures and Measures of Learning of the First Maze

Measure	Total Time r	Total Keys Pressed r	Errors r	Trials r
Pauses	.91	.71	.85	.68
Lapses		.73	.83	.87
Habit interference	.09		.09	.21
Skipping	.19		.08	.23
Letter change	.13		.14	.24
Time change	.50	.40		.11

Partial r, pauses on trials with total time constant: .20
Partial r, lapses on trials with errors constant: .52
Partial r, lapses on errors with trials constant: .27

so the per cent of pause to the total time was small. In the final three trials no pauses occurred. Therefore subjects learning the maze quickly in number of trials would have a comparatively larger total time due to the effect of the last three trials. Likewise, subjects taking a great number of trials would show a larger ratio of total time to pauses, because of the last almost errorless trials. In both cases, however, the time on the last trials was small as compared with the time on the first trials, so that the simple measure which was used may be justified.

Table XV shows the relation of the pauses to the various measures as well as a partial correlation with the total time constant.

A laborious and doubtful study would be accomplished by examining the ratio of the pauses and total time for each trial or for successive fifths of the learning of the maze.

Although this part of the study has not yielded results of a positive character, I feel that the relation of explicit to implicit performance is quite important.

4. *Primacy-Recency*

Meumann (31) stated that when nonsense syllables are learned by the whole method, the first and last syllables are learned most quickly. For a series of 16 syllables the ninth or tenth is acquired last. The curves (Figure 6) illustrate the same type of learning for the letter maze. Here the point of greatest difficulty lay slightly nearer the end of the series. This is explained in the case of the second maze by the uneven character of the material. Meumann attributed this primacy-recency effect to the varying degree of concentration of attention, which he believed was greatest at the ends and least at about the middle. Although attention is undoubtedly a factor, I hesitate to assign the relation found entirely to its working. Rather I believe that it results from the subject's grouping practices. The first letter in the maze offers the natural place to start a group, as does also the last letter, since both can always be identified with reference to something outside the maze. The other groups in the middle are dependent upon vague localizations with reference to the entire maze, such as " near the beginning," " near the end," and " about in the middle." Or these other groups are attached and related to groups which precede or follow them. Forced grouping exists at the beginning, since the subject tries to remember from the first as many letters together as his memory span will permit. Then he generally drops this part and proceeds with the maze. This automatically groups the first letters. Grouping in the middle of the maze has been observed when some combination of letters like *jim* is present or the subject forces a grouping on the series by counting off fives. The grouping process must wait for the groups ahead or behind. These groups must be fairly well stabilized before the first letter following such a group becomes set apart from the group and can serve as the keystone for the formation of another group. One would expect a beginning letter to bring about grouping more easily than an ending

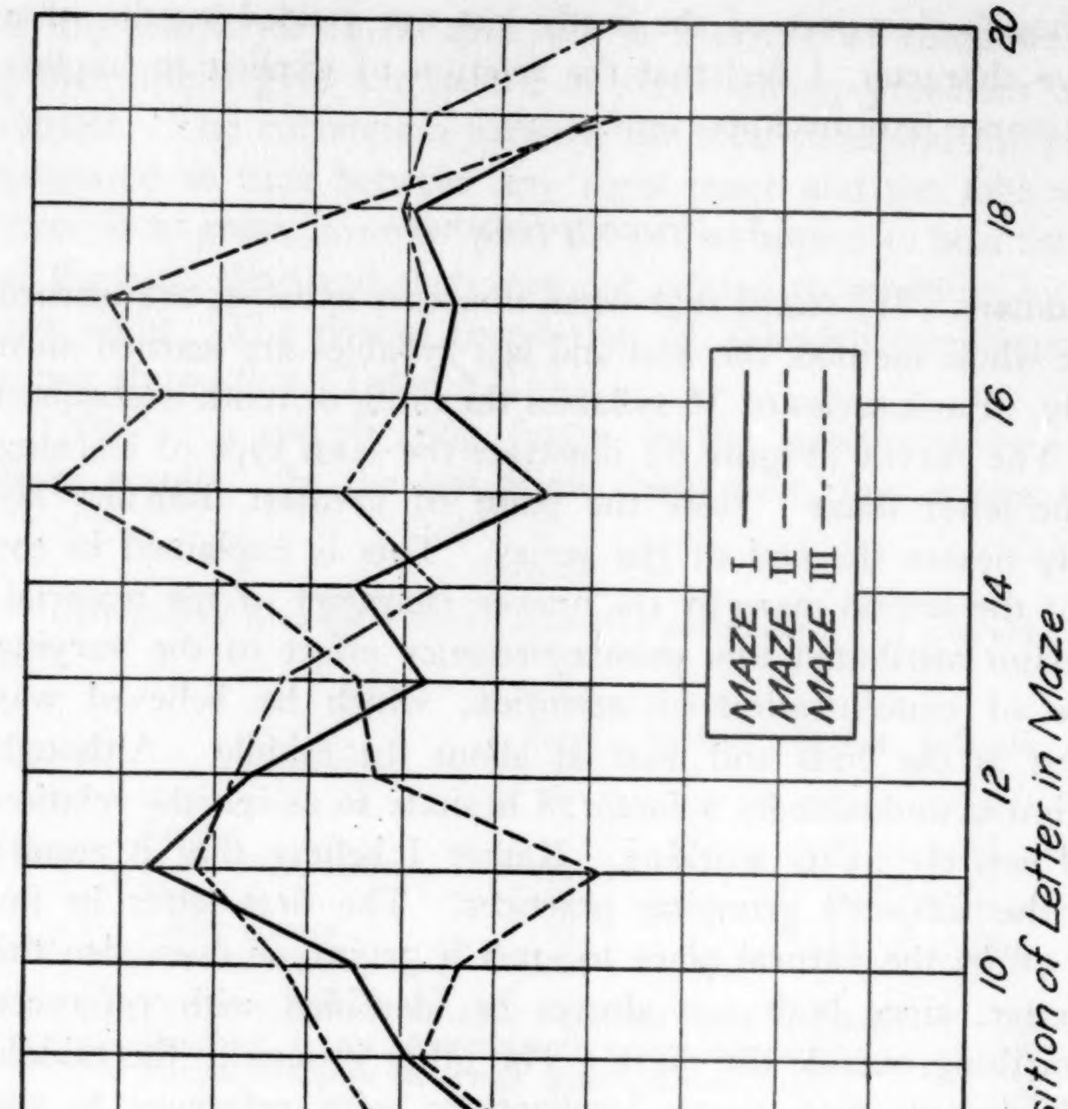


FIG. 6. PERCENT OF ERRORS MADE AFTER FIRST TO NINETEENTH LETTERS

letter, and this seems to be the case, since the groups are built up more quickly from the beginning than from the end.

The fact that different subjects use different groupings is responsible for the smoothing out of the curve. Even so, certain groups seem to have been common to a great many subjects. Such common groups were, as would be expected, mostly beginning groups. The individual learning curves show many instances where whole groups were acquired at once.

5. *Experimental Extinction*

It is commonly reported that repetition of a conditioned response without the presence of the reinforcing agent (unconditioned stimulus) leads to the cessation of the conditioned response. In one sense the oral repetition of the maze by the subject at the end of the learning period was the repetition of a conditioned response without the reinforcing click. The subject usually gave the series orally three times in succession. A comparison of some of these oral reproductions shows that 21 subjects improved from the first to the third oral, and 16 subjects repeated the letters less efficiently on the third trial. Nothing is shown therefore concerning the relation of experimental extinction to the letter maze problem.

6. *Backward Elimination of Culs-de-sac*

The subjects were observed in many cases to put their fingers on a wrong key and then raise their hands and strike another key. Or they approached their fingers to a wrong key and then withdrew them. A typical example is as follows: The subject pressed *I* instead of *L* several times. Then she put her finger on *I* twice but raised the finger again and struck *L*. Finally she merely started her finger in the direction of *I* and corrected this by a hasty movement in the direction of *L* when her finger was near *I*. This seems to me to be analogous to Peterson's (**38**) backward elimination of culs-de-sac, and may be compared with reaching for a hot object and withdrawing before touching, which is observable in adults as well as children. Watson (**48**) mentions that a child, in whom a fear response had been conditioned,

reached for the animal's head upon seeing it but withdrew its hand suddenly before touching the animal.

Presumably the subjects had formed a conditioned avoidance response to the movement of the hand toward the key, since this is the part of the chain of events which occurs nearly simultaneously with the absence of the click sound. It would be interesting to find out whether those subjects who say the letter to themselves as they press a key would build the avoidance response to the letter rather than to the finger movement, or at least along with it. In this case rehearsing the maze verbally, as was often done before striking a key, would result in the rejection and elimination of these wrong reaching movements. On the contrary those subjects saying the letter and then pressing the key should build up the avoidance response to the reaching movements first and these should remain in evidence.

7. *Intercorrelations*

Heron (18) found chance more influential than human individual ability in learning mazes. Hunter (20, 22) has obtained meager correlations for successive performances on the same maze. Davis and Tolman (8) found a correlation of .65 on the error performance of rats on two mazes.

TABLE XVI

Correlations Between Trials of Different Mazes

I & II, r = .71	I & III, r = .76	II & III, r = .67

Table XVI shows the correlation between the different mazes used in this experiment. Trials only were used. There is a fair agreement. There is no reason why a perfect agreement should be expected, and as mentioned previously the study of the individual rates of improvement is more important.

TABLE XVII

Correlations Between the Different Measures of Learning of the Mazes

Measures	I	II	III
Total time, total keys pressed....	.80	.84	.82
Total time, trials.................	.68	.84	.80
Total keys pressed, errors........	.97	.96	.97
Total keys pressed, trials.........	.78	.77	.94
Errors, trials	.88	.87	.95

Much discussion has been held over the selection of the measures of learning. Do trials, errors, or time give the best picture of the learning process? Table XVII presents the correlations between the various measures.

8. *Preference for Letters*

Table XVIII gives the frequencies in per cent with which the different letters were chosen. A is the preferred letter, partly because many subjects used the alphabetical method in hunting out unknown letters. The other vowels were also chosen frequently. The results for all three mazes show major agreement.

TABLE XVIII

The Preference for Different Letters as Errors in Per Cent. Corrected for the Number of Times the Letter is a Right Letter

Maze	A	B	C	D	E	F	G	H	I	J	K	L	M
I	19.9	1.8	2.6	1.5	9.6	2.2	5.2	2.3	14.1	7.2	7.6	11.7	14.1
II	23.1	9.2	6.9	3.6	11.2	3.2	8.0	3.2	6.5	5.9	3.2	5.8	10.0
III	19.1	4.0	4.6	5.3	13.3	5.7	5.8	2.5	10.7	5.9	3.8	12.6	10.0

The letters which were present in the maze the most times were punched the most often as a general rule.

Table XIX presents evidence on this point. This may, however, be an aspect of habit interference or forward association (anticipation). Certainly it seems significant that letters present once in the maze were punched as errors twice as often as those not present at all. Another measure of learning a maze would be the time required for the elimination of those errors (letters) which could never be right.

TABLE XIX

Averages in Per Cents for the Errors Anticipating Letters Which Occurred 0, 1, 2, etc. Times in the Mazes

	Number of Times Letter Occurred in Maze							
Maze	0	1	2	3	4	5	6	7
I	1.9	5.1	9.2	17.0	11.7			
II	3.2	5.6	9.6	12.3				
III		4.4	6.4	12.5	4.6		10.7	12.9
3 mazes	2.2	5.1	8.3	13.6	8.2		10.7	12.9
Omitting A . .	2.2	5.1	8.3	8.2	8.2		10.7	12.9

The last row is computed omitting all the errors made by pressing the letter *A*.

CHAPTER IX

Theoretical Interpretation and Summary

Coghill (7) has presented much evidence to show that the origin of specific behavior patterns is not in the reflex arc, but in an emergence from the total behavior pattern. The amblystoma, the rat foetus, and the human foetus make mass movements of the whole body as the earliest reactions. Subsequently the arms, legs, and finer appendages move without an apparent general or body muscular contraction. Posture of the body, however, is a determining factor in the arousal of certain specific movements rather than others. Thus these movements are obtained as a response to local stimulation only after the body of the amblystoma has been bent to one side, not when the body is straight.

Both Holt (19) and Coghill have pointed out that a process of individuation takes place when conditioned responses are being formed. Not only are the earliest reactions to the conditioned stimulus of a general nature, but the stimuli which will elicit the desired response are numerous. Liddell * has shown this generalization of responses with experiments on the conditioning of sheep. Pavlov (36) himself has called attention to the second phenomenon. He gives this the name of *generalization*. If a dog has been conditioned to a tactual stimulus on one part of its body, it will also respond when other more or less adjacent areas are stimulated. The restriction of this sensitized tactual field to one spot is known as *differentiation,* and is accomplished by failing to reinforce the tactual stimulation of any other areas.

In the broadest sense the process we call *abstraction* is akin to this differentiating process. At first the whole situation acts as the stimulus, as can be shown by bringing the individual into a totally new environment. Gradually certain aspects of this

* Reported by G. E. Coghill in a talk given at the Ohio State University, 1931.

situation become prepotent in eliciting responses. This narrowing down of the field of stimulus-response may be brought about by the development of adaptation and avoidance responses to the other parts of the stimulating situation. As an example of adaptation our disregard for the skin stimulation occasioned by wearing clothes may be cited. The behavior of animals may be limited by the formation of avoidance responses to electrical stimulation as in Warden's (47) experiment. Abstraction proceeds along two dimensions. First there is an analysis of the total complex relationship existing at any moment into other relationships which we are accustomed to classify as simpler. The person who hears individual tones when a chord is sounded and sees parts of a visual form experiences this kind of resolution. Secondly, the time factor must be emphasized. From a series of movements certain ones may be abstracted, *i.e.,* selected. Likewise changing visual and auditory patterns undergo this temporal type of analysis. The foreigner, who picks out a few words from an English conversation, has made temporal abstractions.

The learner brings to the solution of the letter maze a great many possible responses. These, when applied to this new situation, give the appearance of mass movements, random movements, or undifferentiated movements. The subject cannot strike all the keys at once; hence there is a shift from one response to another. The same principle may be observed in the various movements that a baby makes, where certain movements are rendered impossible by reason of the execution of physically opposed movements. But the striking of this or that particular key is called a chance movement, because the essential conditions for the production of this particular movement do not seem to be directly related to the stimulating condition as the experimenter sees it, namely the series-to-be-learned. Very shortly, however, a relationship between the responses and the series-to-be-learned is observed. This is the so-called tendency to anticipate, discussed in Chapter IV. The first appearance of this anticipation tendency bears a striking resemblance to *generalization,* and its further development to *differentiation* as given by Pavlov for

conditioned reflexes. The subject strikes keys which are related by contiguity with the right response key in much the same way that the dog responds to tactual stimulation of areas adjoining the reinforced area. The concept of generalization can be applied to the stimulus, following Pavlov's custom, or it can be applied to the response. As Holt has suggested, the truer picture would include both aspects. With reference to the letter maze the various letters and the positions in the temporal sequences may be looked upon as the stimulating situation. At any given point in the maze the letters which are correct at the surrounding points should release the approach response. In the present investigation the letters forward in the series seem to do this. This is generalization with respect to the stimulus, since other stimuli bring about the same (approach) response. As a specific example the point B in a series *A B C D E,* etc., may be taken. The subject just beginning to learn this series should respond with an approach reaction if *A, C,* or *D* is shown. Evidently the letters of the surrounding points are therefore also efficient in bringing out the response. Generalization by contiguity has taken place.

Or the stimulating situation may be thought of as relatively constant and the variation as occurring in the response. Here the stimulating situation is the point of choice in the maze. The response made is the depression of one specific key or another. In this case the point B in the series may bring about the response of approaching *A, C,* or *D.* It is at once apparent that the distinction between these two types of generalization depends solely upon the definition of stimulus and response. There have been sufficient papers written since the time of Dewey's (9) reflex-arc concept article to point out the impossibility of isolating one or the other. Should the response be defined as (1) an approach reaction or (2) an approach reaction to a certain key? It seems to me that it is a matter of indifference. Generalization is thus an apparent lack of specificity in the stimulus-response interrelationships.

Differentiation, on the contrary, seems to be the emergence of specific responses to specific parts of the stimulating situation.

This does not imply that a specific response is the action of one muscle or that only one nerve path is concerned. Without going to the other extreme and assuming a purposive organization of the bodily activity, such as activity pointed towards a goal, we can say that the whole activity is organized in the same way that the arrangement of iron filings around a magnet constitutes an organization. The emergence of certain activities is what we observe and classify as reaching, running, etc., in a social sense. This does not say that only the muscles in the arms or legs respectively are active. There is no reason to suppose that such total activity cannot be carried out by means of a pathed nervous system and chemical correlation.

In a very genuine way such social units seem to develop as the differentiating process continues. The subject learning a series of nonsense syllables usually knows each one separately during the course of the experiment. In pursuitmeter learning Renshaw (39) found that subjects first show gross arm movements and eventually fine adjustments of the fingers. Similar observations have been reported bearing upon piano playing. There are two reasons why the differentiating process does not continue indefinitely with smaller and smaller units resulting. The first of these reasons has its source in the limitations of the sense organs. Obviously a partly blind man can not make extensive visual discriminations, nor can a person with normal eyesight make an infinite number of varying responses to visual situations. Secondly, the organism is seldom required to make fine discriminations. When a list of nonsense syllables is read to the subject, he must discriminate the pronunciation to a certain extent, but not necessarily the intonation. We usually discriminate just as finely as is necessary for learning.

All new experiences are interpreted with reference to previous experience. These previous experiences determine what " random " movements shall be made. Often during the progress of the differentiation a separated or abstracted part will be associated with some previous experience which can serve to initiate the proper responses. The sequence *L I K E* becomes identified with *like* and so arrests the further separation into *L* and *I* and *K* and *E*.

Coming shortly after or even along with the process of individuation is an opposed or integrative process. The finished performer shows just as much mass action as the beginner, except that the mass action of the former is socially acceptable and recognized socially as organization. Learning then appears to be the process of shifting from one type of organization to another type of organization. Usually the latter organization is judged as more suitable. Accompanying the first part of the integrative process is the phenomenon of habit interference, provided the type of units differentiated out makes this possible. Habit interference can occur when two similar units are followed by different units. It should not be present while differentiation is taking place, because the units are then not well defined. It should not be present after the integrative process has started to recombine these units. The experimental evidence given in Chapter V seems to show that *habit interference is most pronounced just before the maze is completely learned and after the anticipation tendency has passed its peak.* An illustration showing the presence of these units and the difficulties entailed by their many associations is taken from Thorndike's (44) work. He gives the results of questions asked children on a given paragraph of reading. The answers show that the children did not grasp the sense of the question as a whole, but replied to some word or phrase which it contained. One question was, " What is the general topic of the paragraph? " and 3 per cent of the children replied that it was " a group of sentences." To the adult the question presents what seems to be a unitary idea. Speed in understanding foreign languages is largely dependent upon seeing the meaningful woods in spite of its many individual trees.

Methods of improving this readjustment or reorganization necessary in learning should be those aiding differentiation and integration, and facilitating especially the short cut between the two. This short cut might be looked upon as the insight of the Gestalters. It occurs when a present experience is interpreted in terms of a form or integration previously acquired. The subjects, who, after having found the letters *C H E M I,* finished the sequence by pressing *S T R Y* or *C A L,* showed this partial

analysis or differentiation of the new situation and the immediate transfer to an old integration.

Self instruction is a method which would limit the types of responses and therefore aid in differentiation. If the subject says, " I will respond to this part of the situation only, the letters *A to M*," he helps himself in differentiating that part of the situation further by ignoring the rest.

Naming is a process of differentiation. Lehmann (27) found that giving names aided subjects in learning to distinguish different grays. Verbal methods easily lend themselves to manipulation. Parts of situations may be abstracted and named. These named parts can be then combined. Furthermore, naming things relates them to the many other words and suggests the operations which are carried out on words. The same thing is done more exactly when mathematics is used. Naming does not always aid the learner, however. Some acts can not be isolated sufficiently to be given a name. In addition a possible combination of names does not always represent a combination of physical movements which is possible. We may talk about raising the right leg and the left leg and then combining the two movements simultaneously, but we can not execute this double flexion of the legs without some further adjustment of the rest of the body. It is precisely because the movements of the whole body are important with reference to part movements and vice versa that this naming or recombination of abstractions breaks down. At the same time the influence of the whole or of other members is either considered in employing the part, or may be neglected. Experimental science is based upon the principle that those aspects of the whole situation which will markedly influence the results should be eliminated. Since there is a limit to experimental control, the investigator tacitly assumes that those aspects of the whole situation which he does not remove are relatively unimportant.

In Chapter III the question of the priority of form in giving the parts as compared with the development of the form from parts was discussed. If the individuation-integration series is short-circuited, then the form or whole through which this short

cut is made seems to give the parts. On the other hand the regular analysis and synthesis may take place, and it seems as if the form arises from the parts. The discovery of the word *imbecile* in the third maze and the pressing of the keys *I M B* etc. (parts) may be given as an example of the first case. The construction of the word ***bacillus*** from the combinations *be, c,* and *ill* can be interpreted as an illustration of the second type. It is evident that the whole problem of form determining parts and parts determining form rests upon an analysis or abstraction of certain parts of behavior out of the continuous changing whole and the ascription of casual power to these parts or to the whole in relation to these parts. One should be content with a description of the relations that exist between the so-called wholes (which are of course themselves parts) and the sub-wholes or other parts.

The course of learning may be characterized as a change to what we call an integrated action from what appears to us to be a mass action, but is nevertheless a physical organization. To achieve this the response-stimulus situation must be differentiated into pseudo-units and recombined. Studies of these pseudo-units should show the tendency towards anticipation at first, then habit interference or conflicting associations, and finally complex building. Spencer (43) formulated a theory in which he represented evolution as a process of differentiation and specialization of parts from something very simple, quite inchoate, yet homogeneous. These parts then integrated and combined with other parts, making articulated wholes. Whether one can ever say anything about the original homogeneity of behavior is problematical, but otherwise this differentiation and integration which Spencer found in evolution appears in the process of learning. This is not strange. For what is learning but an evolution of behavior?

We consider learning in a social sense as the description of behavior by someone. It is evident therefore that the experimental psychologist has an immense field for research in the description of the conditions resulting in the reorganization of behavior. This type of analysis should be made first. When these functional relationships have been determined, then the

correlation of nervous action with behavior may be attempted. Our wealth in theories of neural action, such as drainage, irradiation, etc., is a confession of the poverty of functional or behavior descriptions which are available as a basis.

Summary

1. Verbal grouping appeared to be more effective in learning the mazes (letter series) than other types of grouping.

2. The subjects who easily identified the new groups with groupings already learned in the past mastered the mazes most quickly.

3. A tendency to anticipate letters further on in the mazes was shown. This was determined from the types of errors made.

4. Subjects who organized the maze in verbal terms showed less habit interference than those using motor methods.

5. If, in a case where mutual interference was possible, one of the groups was verbal and the other motor or unidentified, the chances favored the motor or unidentified groups showing the interference.

6. The proportion of habit interference errors increased until the maze was almost completely learned.

7. No relation between the variability of the responses and the measures of learning was found.

8. Those subjects who repeated errors twice or made immediate repetitions tended to make better scores than those repeating but once. This result is, however, inconclusive.

9. A slight relation between intelligence-test scores and maze performance was found.

10. The first and last parts of the mazes were learned more quickly than the middle.

11. The subjects were observed to make movements analogous to the backward elimination of a cul-de-sac, or partial entries.

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